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(SUPPORTED BY THE DE LAMAR FUND OF THE JOHNS HOPKINS UNIVERSITY)

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January, 1947

Objective Studies of Some Physiologic Responses in Mild Chronic Trench Foot. G. E. Burch, M.D., Major Harvey L. Myers, M.C., Lt. Col. Reno R. Porter, M.C., and Major Nathan Schaffer, M.C. 1

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OBJECTIVE STUDIES OF SOME PHYSIOLOGIC RESPONSES IN MILD CHRONIC TRENCH FOOT*

G. E. BURCH, M.D.,[1] MAJOR HARVEY L. MYERS, M.C.,[2] LT. COL. RENO R. PORTER, M.C.,[2] AND MAJOR NATHAN SCHAFFER, M.C.[2]

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Col. A. P. Upshur, M. C., Commanding Officer of the LaGarde General Hospital provided significant assistance in these studies.

M.L.

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I. INTRODUCTORY REMARKS

The clinical picture of trench foot has been exhaustively described in the literature by many authors. It is not the purpose of this report to review the problem of trench foot. A well accepted symptom complex as well as clinical observations have been delineated in all of its phases from its inception until the late chronic phase of the disease. This work is to be limited to a series of physiologic observations on mild chronic trench foot of a degree bordering on normalcy which might ultimately lead to the improvisation of a simple objective test which can not only demonstrate the existence of trench foot but also, to some extent, the degree of severity, or at least differentiate between the presence or absence of activity. An absolutely infallible test is certainly not available, but the results strongly suggest that it is possible to demonstrate the existence of activity and degree of involvement. It is well to realize that data obtained on chronic trench foot with mild involvement will differ qualitatively and quantitatively from those of the acute phases of the disease. There is a high negative

correlation between the time at which the injury was incurred and the acuteness of the process at the time of testing. The tests to be described tend to indicate that the trench foot process is in reality an inflammatory process, an inflammatory process produced as a result of injury from physical agents, namely cold and wet. This injury, aggravated by constricting foot gear, prolonged dependency, immobilization, deficient nutrition and so on, may be superimposed with secondary infections entering through avenues provided by tissue destruction. Trichophytosis, which is very common among patients with trench foot, may also provide avenues of entrance for secondary infections. Inflammation, as defined by Dorland, (1), is "the condition into which tissues enter as a reaction to injury (Adami). Inflammation is characterized by pain, heat, redness and swelling, histologically by hyperemia, stasis, changes in the blood and walls of the small vessels and by various exudations." Inflammation falls into acute, subacute, and chronic stages. The acute inflammation, as far as trench foot is concerned, is first manifested by intense hyperemia. There is swelling, redness and pain in a warm extremity. This acute phase has been referred to as the *hyperemic or inflammatory stage.* It may last from a few days to a few weeks. Subacute and chronic stages of inflammation may be designated as the posthyperemic (apparently a misnomer) stage, during which time reaction is subsiding and repair has begun. The transition from the stage of acute inflammatory reaction to the stage of repair is insidious and extremely variable. These two stages always overlap, so that while a limited amount of the early type of reaction still exists, repair may be in full swing.

Although the literature on the pathology of trench foot leaves many questions unanswered, both gross and microscopic studies repeatedly refer to tissue changes which leave no doubt of their identity with inflammation, involving not only the epidermis and its appendages, such as the sweat glands, hair follicles and sebaceous glands, but also the dermis, subcutaneous tissues, fat, muscle, nerve, bone and, of course, the blood vessels. These evidences of inflammation were found not only in acute stages but also many months after the initial injury (2).

Since the manifestations of inflammation are pain, redness, swelling

and heat, observations of these cardinal features will indicate the presence and degree of inflammation. Pain is very difficult to evaluate objectively. Variations in the amount of circulating hemoglobin, pigmentation, thickness of the epidermis, and lighting, limit skin color studies as a means of evaluating circulation. Swelling, especially in the late or chronic phases of disease, may exist and frequently does, but its measurement is a practical problem difficult to surmount. Temperature, on the other hand, may be easily and accurately measured (0.1 to 0.2°C.) by means of thermocouples. Because of this, the study has been mainly limited to the use of thermocouples. It is purely an objective method which is not subject to influences. The temperature of a part is closely correlated with the degree of inflammation in that part, providing other factors which produce elevated temperature can be ruled out. These factors are usually constitutional rather than local. For example, if the individual is experiencing an elevation of temperature due to generalized disease, this will, of course, be reflected in the extremities. An endocrine imbalance, such as hyperthyroidism, will cause the extremities to become warm. Psychogenic factors will influence the temperature of an extremity. In the course of these studies an attempt was made to eliminate the extraneous local and general causes for elevation of the temperature of a part and evaluate only the temperature changes produced by factors intrinsic in the part which bears relationship to the trench foot.

Assuming that the temperature of the part will be an index of the existence and degree of inflammation in that part both as to reaction and repair a person with severe trench foot may have a lower surface temperature of the part involved than one with a mild case, if these two determinations are made at different times in relation to the time of onset. For example, the patient may have a considerable degree of tissue damage and tissue loss with only moderate deviation of the temperature above normal, providing the relationship between the date of onset of the trench foot and the determination of the temperature are sufficiently far apart. When tissue loss or severe damage is present it is usually obvious to the examiner. A test which could demonstrate the existence of inflammation in the presence of a minimum amount of clinical evidence of damage would be of great value. In brief, at the conclusion of the various physiologic studies described

below a significant problem may be summarized as to confirm or to deny the existence of inflammation in mild chronic trench foot in the absence of definite objective findings, and in spite of subjective complaints.

The exact pathogenesis of trench foot is not known. It has not been definitely established that all injuries resulting from cold or low temperature may be placed in one category from the standpoint of tissue pathology. Certainly, tissue injuries produced by chilling under conditions much below freezing may differ from injuries produced by temperatures above freezing. "Wet Cold" is especially damaging because water has a high capacity for removing heat by conduction from an extremity, about 27 times that of air. Therefore, exposure under weather conditions existing during a thaw may result in greater disability than is incurred in actual freezing temperature because of the influence of the water. Exposure to "wet cold" for prolonged periods, of course, will produce a more profound and far reaching reduction of tissue temperature of the exposed part than short exposures. "True frostbite" does not show uniform necrosis throughout the deeper tissues, although areas of pathology similar to those found in tissues subjected to temperatures above freezing may be seen. All other factors being equal, "wet cold" produces a more diffuse or penetrating effect than "dry cold" just as "wet heat" produces a more diffuse and penetrating effect than "dry heat". This may account for the fact that although trench foot may demonstrate less superficial involvement of tissue, the disability in trench foot patients may be greatly prolonged over patients with frostbite in which the degree of superficial tissue destruction is much greater. The diffuse and deep injury to tissues tends to explain the existence of an inflammatory process months and possibly even years after the initiating cause has been removed. The premise that inflammation, including both reaction as well as repair, may reside in tissues long after the initial injury is by no means a new one, peculiar to trench foot. Burns, particularly scalds, which may be associated with little evidence of superficial reaction in the later stages, may result in prolonged disability due to diffuse deep tissue damage. Certainly, burns produced by chemicals and radiation result in chronic reaction in tissues. Inflammation under these circumstances may exist long after the initiating cause has been removed (3, 4).

II. METHODS AND MATERIALS

1. *Procedure of Study in General*

The subjects were made to rest in bed, unclothed and covered with a sheet in an air conditioned room. Thermocouples were placed upon the upper and lower extremities. After stabilization of skin temperatures was obtained, the arterial and venous circulations to the legs were suddenly occluded bilaterally by a pressure cuff around the lower third of the thigh. After 15 minutes of occlusion the pressure was released and circulation re-established. Temperature determinations were made continously *ad seriatum* throughout the period of study. During the course of these observations, variations in skin color, intensity and duration of reactive hyperemia, and rate of refilling of skin vessels were noted. The additional procedure of unilateral blocking of the posterior tibial nerve with procaine was performed in some of the studies. Identical observations were made on both trench foot and control subjects, simultaneous studies being conducted whenever practicable.

A group of subjects, both normal and those with trench foot, were observed for insensible and sensible perspiration. Sensible perspiration was initiated by a very hot and humid environment.

2. *The Subjects*

The subjects studied were:

Trench Foot Patients: Patients with uncomplicated trench foot were transferred by railroad from the Brooke General Hospital of the U. S. Army and the U. S. Army General Hospital at Camp Butner, North Carolina, to the LaGarde General Hospital of the U. S. Army at New Orleans. They were then transported, via ambulances, from the LaGarde Hospital to the laboratories at Tulane Medical School for observation. With only a few exceptions the patients were ambulatory. The patients were mainly injured during the "Battle of the Bulge" in Belgium. The date of injury and length of time since injury are indicated in detail in Table 1. Also shown in Table 1 are details of age, duration of trench foot symptoms, degree of damage, and other miscellaneous factors of clinical and biographical interest. The patients with trench foot totaled 46, and ranged from 19 to 36 years in age. All of them were males; 44 white and two colored.

To correlate the laboratory findings with the clinical manifestations it became necessary to classify the patients under study into clinical types, or classes, of severity. Although it would have been valuable to include in this classification the severity of the initial state, it was impossible to evaluate this because of the meager information available on the medical record and the unreliability of the past medical history derived from each patient. Furthermore, since the present studies were concerned primarily with the chronic phases of the disease, this information was not essential. The classification employed in these patients was made simple and depended mainly on objective clinical data. The classification as used elsewhere (5) obviously could not be employed in these patients.

Classification of the Chronic Stage of Trench Foot: Class I: (a) Patients with practically no objective findings, all complaints being subjective in nature. Existence of disease may even be subject to question. (b) Patients with mild erythema of toes, slight dependent edema, and some slight limitation of motion of the toes. (c) Patients with obvious edema, definite erythema, tenderness on pressure, limitation of motion of toes, and possible small ulcerations or areas of desquamation, and with obvious walking difficulties.

Class II: Patients with swelling, erythema, definite loss of tissue, not including spontaneous amputation of an entire toe; some fairly large areas of ulceration and tissue loss. The patient is able to stand on his feet with some difficulty.

Class III: Patients with spontaneous amputation of at least one toe, marked reaction of inflammation with edema and erythema. Patient is unable to walk and has pain even while at rest in bed.

Since almost all of these patients were of *Class I* and they varied in degree within this Class, the Class was further subdivided into three subclasses. Therefore, with such a classification, it was possible to code the severity of the patients by symbols. For example, Ib would be employed to indicate a patient with chronic trench foot of Class I and subclass b, and so on.

Normal Subjects: There were 108 normal volunteer subjects varying in age from 19 to 40 years. There were 89 males and 19 females (latter volunteers from the Women's Army Corps). The males were soldiers from the detachment at LaGarde General Hospital, a few

TABLE 1

SUBJECT	AGE	HOME STATE	MONTHS IN SERVICE	WHERE SYMPTOMS BEGAN	DATE ONSET OF SYMPTOMS	DATE OFF LINE	TIME IN MTHS. FROM ONSET TO TIME STUDIED	PREVIOUS FOOT TROUBLE	PREVIOUS TROUBLE WITH TEMP. CHANGES	CLINICAL EVALUATION		AMPUTATIONS
										At onset	At present	
G.I.	25	Ill.	15	Belgium	1/ 8/45	1/10/45	5	None	None	Mod.	1c	None
J.S.	19	Ala.	14	Belgium	1/ 9/45	1/10/45	5	None	None	Severe	111	1, 2, and 3rd. toes rt. ft. all toes lt. ft.
E.A.W.	23	Tenn.	62	Belgium	12/28/44	1/ 7/45	5	None	None	Severe	111	All toes both feet.
D.E.I.	19	Mo.	14	Belgium	1/10/45	1/12/45	5	None	None	Severe	111	All toes both feet.
C.E.C.	22	Ala.	29	France	12/ 3/44	12/ 5/44	6	None	None	Mod.	1a	None
W.F.	19	Ark.	15	France	2/ 7/45	2/ 7/45	4	None	None	Mod.	1c	None
H.A.D.	22	Ohio	12	Belgium	12/28/44	1/23/45	4½	None	Cramp in feet while swimming	Mod.	1c	None
F.P.W.	26	Texas	68	Belgium	12/25/44	1/ 2/45	6	Flat feet	None	Severe	111	All toes right foot.
J.A.	23	Ala.	43	Germany	11/22/44	11/28/44	7½	Burnt as a child both ft.	Both legs fracture	Mod.	1c	None
S.J.C.	20	La.	23	France	1/ 2/45	1/ 6/45	5½	Flat feet	None	Mod.	1b	None
W.H.	24	Miss.	13	Germany	1/12/45	2/ 3/45	5	None	Swimming cramps legs thighs	Mod.	1c	None
L.B.J.	22	Wisc.	23	Belgium	12/19/44	12/23/44	5½	None	Frostbite feet.	Severe	111	First and second toe left foot.

Detail clinical and biographical information on the patients with chronic Trench Foot are included in these studies.

E.G.C.	25	Ill.	12	Germany	1/11/45	1/24/45	4½	None	None	Severe	1b	None
C.L.	24	Tenn.	36	Belgium	1/21/45	1/21/45	7½	None	None	Mod.	111	Fourth and fifth toe right foot.
L.P.C.	23	La.	27	France	3/15/45	3/15/45	7	None	None	Mod.	1a	None
B.A.S.	19	Texas	13	Germany	2/24/45	2/24/45	6½	None	None	Mod.	1a	None
G.H.L.	22	Texas	36	Germany	2/ 2/45	2/ 2/45	7	None	None	Mod.	1a	None
R.H.H.	22	Texas	33	France	12/ 9/44	12/ 9/44	9	None	None	Mod.	1a	None
H. J. G.	24	Ala.	11	Germany	1/10/45	1/10/45	6	None	None	Mod.	1b	None
E. W. H.	23	Ark.	30	Belgium	1/ 5/45	1/ 5/45	8	None	None	Mod.	1a	None
J. W. G.	25	Wisc.	24	Germany	2/ 9/45	2/ 9/45	7	None	None	Mod.	1a	None
W. T.	19	Okla.	8	France	2/ 5/45	2/ 7/45	4	Flat ft.	None	Severe	111	First and second toes right foot.
C. M. G.	23	Texas	13	Luxem.	1/15/45	1/28/45	4½	None	Cramp in foot while swimming	Mod	1a	None
E. C. Mc.	30	Ark.	12	France	11/15/44	11/18/44	7½	None	None	Mod.	1a	None
H. L. J.	25	Ala.	13	Belgium	1/ 8/45	1/ 8/45	6	None	None	Mod.	1a	None
L. H. L.	19	Ark.	11	Luxem.	1/21/45	1/21/45	4½	None	Cramp while swimming	Severe	1a	None
L. L. N.	34	N.C.	16	Italy	1/ 7/45	1/ 7/45	5	None	None	Severe	1b	None
B. C.	25	Texas	33	Italy	4/14/45	4/14/45	5	None	None	Mod.	1a	None
R. L. T.	19	Mich.	12	Belgium	1/11/45	1/11/45	5½	None	None	Mod.	1a	None
S. W. N.	25	Pa.	14	Germany	2/ 5/45	2/ 5/45	7	None	None	Mod.	1a	None
W. O. S.	24	Texas	34	Germany	2/ 9/45	2/ 9/45	7	None	None	Mod.	1a	None
J. L. D.	22	Ala.	27	Belgium	1/25/45	1/25/45	4	None	Cramp while swimming	Severe	1b	None
G. J.	33	Mich.	35	Germany	1/28/45	1/28/45	7	None	None	Mod.	1a	None
B. K.	34	Pa.	14	Germany	12/14/44	12/16/44	5½	None	None	Mod.	1a	None
G. A.	28	Ind.	50	Belgium	1/11/45	1/11/45	5	None	None	Mod.	1c	None

TABLE 1—*Concluded*

SUBJECT	AGE	HOME STATE	MONTHS IN SERVICE	WHERE SYMPTOMS BEGAN	DATE ONSET OF SYMPTOMS	DATE OFF LINE	TIME IN MTHS. FROM ONSET TO TIME STUDIED	PREVIOUS FOOT TROUBLE	PREVIOUS TROUBLE WITH TEMP. CHANGES	CLINICAL EVALUATION		AMPUTATIONS
										At onset	At present	
G. R. B.	21	La.	24	Germany	12/10/44	12/15/44	6½	None	Frostbite feet	Mod.	1a	None
J. R. C.	36	Ala.	14	France	11/30/44	11/30/44	7	None	None	Mild	1a	None
H. R. K.	21	Texas	25	Germany	2/25/45	2/ 5/45	4	None	None	Severe	111	All toes both feet.
H. C. J.	25	Ga.	55	Belgium	12/25/44	12/26/44	5½	None	None	Mod.	1a	None
C. A. S.	20	Tenn.	14	Belgium	12/25/44	12/28/44	6	None	None	Mod.	1a	None
J. F. D.	22	N.C.	30	France	11/ 6/44	11/14/44	6½	None	Rt. ft. frostbite	Mod.	1b	None
W. K. W.	33	Miss.	44	Germany	12/10/44	12/11/44	7	None	None	Mod.	1a	None
C. B. H.	33	Ala.	15	France	11/14/44	11/15/44	7½	None	None	Mod.	1a	None
E. J. M.	25	La.	41	Holland	11/ 2/44	11/27/44	7	None	Cramps while swimming	Mild	1a	None
H. L. S.	20	Ala.	26	Germany	1/27/45	1/29/45	6	None	None	Mod.	1a	None
J. C. C.	22	Miss.	16	Italy	2/ 7/45	2/10/45	7	None	None	Mod.	1a	None
H. B.	25	Texas	15	Italy	2/11/45	2/11/45	7	None	None	Mod.	1a	None
C. H. R.	33	La.	34	Germany		12/25/44	5	None	None	Mod.	1a	None
J. D. L.	19	La.	13	Germany	1/—/45	2/—/45	3	None	None	Mod.	1a	None

convalescent patients at the Hospital awaiting discharge, and medical students, technicians, and doctors from the Tulane Medical School. All were known to be in good health and free from any organic disease. None of these patients had had any severe peripheral vascular disease in the past or had suffered from frostbite or any type of injury from cold. These subjects, like the patients with trench foot, were well acquainted with hospital routine and aspects of clinical investigation and tests.

Patients with Psychoneurosis: There were 51 volunteer patients with psychoneurosis. They were from the LaGarde General Hospital and had been under observations for prolonged periods of time, thus offering adequate opportunity of eliminating organic disease. They were all male soldiers varying in age from 19 to 37 years and were transported via ambulance to the Tulane laboratories for study.

Patients with Miscellaneous Vascular Disease States: Several patients with peripheral vascular disease were studied along with those described above. They were divided as follows: three frostbite, one varicose veins, one Raynaud's disease. These few patients were included for orientation purposes.

Almost all of the patients and subjects described above had epidermophytosis of the feet to a mild degree. Subjects with severe epidermophytosis with secondary infection were not studied.

3. *Conditions of the Observation Room and Preparation of Patients*

a. *Conditions of observation room:* At the onset of the studies it became necessary to choose room conditions obtained by air conditioning apparatus. In order to find the most satisfactory atmospheric conditions, a series of preliminary studies were conducted on normal young adult male subjects and a comparable series of young male soldiers with mild chronic Class I trench foot under room conditions varying in temperature from 14.5°C. (58°F.) to 25.5°C. (78°F.) and relative humidity varying from 50 to 65 per cent. All subjects rested in a comfortable hospital type bed and were nude except for an ordinary type of cotton sheet, which covered their trunks and upper third of the thighs. It was soon found that at temperatures below 18.3°C. (65°F.) most of the normal and trench foot subjects complained of being cold and insisted that they were uncomfortable. Many of

them had a real chill or rigor. At 18.3°C. (65°F.) several subjects had a rigor near the end of the study, which necessitated about 90 minutes stay in the observation room. When room temperatures above 21°C. (70°F.) were used, differences between the normal subjects and those with trench foot, following the reactive hyperemia test (described in detail elsewhere in the paper), were not very great. This was particularly apparent at temperatures of 23.8°C. (75°F.) or higher. When a temperature of 20°C. (68°F.) was used, the subjects found the room pleasantly cool, a sufficient gradient existed between the temperature of the part and that of the room air, to bring out differences in vascular reactions to such stimuli as reactive hyperemia, complete occlusion of arterial and venous circulation of the part, and to nerve block.

It was also found that at a room temperature of 20°C. (68°F.) the relative humidity could vary from 50 to 65 per cent without producing any notable differences in the results. This is of particular importance, since it is difficult, if not impossible, to guarantee a constant relative humidity for prolonged periods of time without a vapor sealed room. The rate of movement of the room air should not exceed 15 feet per minute. Since thermocouples sealed with "Scotch Tape" to the surface of the parts studied measure a temperature on the skin surface determined by a state of equilibrium between the atmospheric temperature and temperature of the part, it was necessary to maintain a constant room temperature, to a variation of less than 0.55°C. (1°F.).

b. *Influence of clothing:* It was noted that if patients were covered with a sheet and woolen blanket (standard type of blanket issued by the U. S. Army) many of the subjects were too warm. Some of them perspired a great deal and showed considerable fluctuations in foot and toe temperatures. In order to standardize the conditions, they were all stripped of their clothing and then covered over the trunk from the shoulders down to include the upper third of the thighs. Under these latter conditions some of the subjects experienced subjective coolness; the large majority were comfortable and enjoyed the atmospheric conditions. None were truly uncomfortable. It is well to emphasize the importance of not varying the amount of clothing. This is well brought out in the studies on the normal females (W. A. C.) in whom the clothing could not be properly controlled.

c. *Weather conditions:* Since it is quite likely that the local weather conditions influence the results of such a study as this, the New Orleans weather during the months of May through September 1945 are summarized in Table 2. These are the warmest months of the year for New Orleans.

d. *Meals:* A series of studies were conducted on subjects with and without the previous meal, that is, the subjects studied in the morning did not eat breakfast and those studied in the afternoon omitted lunch. The subjects who omitted previous meals complained of hunger and showed signs of restlessness and impatience. Since it

TABLE 2

A Summary of the Weather Conditions in New Orleans during the Period of These Studies

	TEMPERATURE (°F.)			RELATIVE HUMIDITY (%)		
Month	Mean	Max.*	Min.*	Mean	Max.	Min.
May	75.0	83.2	66.7	71.5	96	42
June	82.9	91.0	74.8	77.8	98	51
July	81.6	87.4	75.7	83.0	99	57
August	83.0	89.2	76.7	82.3	99	47
September	81.4	88.5	74.3	80.3	98	49
Average for entire period	80.8	87.9	73.6	79.0	99	42

* These values are the mean of the extreme temperatures.

was found that the results were not influenced by eating or omitting meals the routine was soon established of permitting all subjects to eat before coming to the laboratory for study. By adopting this routine all patients went from two to three hours without food before observations were begun. Permitting patients to eat at regular Army mess hours simplified the management of the subjects, and avoided the complaints associated with hunger without altering the results.

All subjects were asked not to smoke before the studies, although occasionally we encountered a subject who disobeyed the request. None of them, however, smoked, drank or ate anything once they entered the laboratory for study. Subjects with complicating diseases were not studied.

4. *Description of the Occlusion-Reactive Hyperemia Test*

This procedure was chosen since it was simple to employ and was entirely objective. It was free from any need for cooperation from the subject (except remaining fairly still). It can result in a test of the ability of the vessels of the feet to dilate under intact physiologic conditions. This latter bit of information is important since it is valuable to know some aspects of the ability of the blood vessels of the part to deliver blood to the part to meet requirements of metabolism, thermoregulation and repair. The integration of the functional state of the vessels with the anatomic changes should be observed under the influence of the intact physiologic factors governing the adjustments of the circulation of the part. The test described below gives some indication of these.

The test as employed was as follows:

The subjects entered the observation room, undressed completely, entered a comfortable hospital type bed and were covered with a single cotton sheet from their shoulders to the upper third of the thighs. Blood pressure cuffs with six foot lengths of added cloth were snugly but not tightly wrapped around the lower third of the thighs. These cuffs connected to a metal pressure tank kept automatically at 280 m.m. of Mercury pressure by means of a reduction valve and the air pressure supply of the laboratory. Constantan-copper thermocouples were then placed on five areas, four on each foot commonly showing the most damage from trench foot and one on the middle finger. These points were: (1) the "bunion area"[3] (medial aspect of the first metatarsophalangeal articulation); (2) the pad of the terminal portion of the great toe; (3) the pad of the terminal portion of the second toe; (4) the "corn area"[3] (lateral aspect of the first interphalangeal articulation of the fifth toe); and (5) the pad of the terminal portion of the middle fingers. By means of a decade switch, each thermocouple was switched into series with a galvanometer and the temperature of the part was measured to within 0.1°C. The temperature of the 10 points was measured continuously *ad seriatum*. When the temperature of all parts reached a fairly constant level (maximum variation in any one part of 0.4°C.), usually requiring

[3] These terms are employed for the sake of brevity.

about 30 minutes, *Phase I* of the test was completed. *Phase II, the period of occlusion*, of the test was started by sudden occlusion of the arterial and venous circulations by sudden opening of a valve and connecting the cuffs around the legs to the pressure tank. This resulted in cessation of the circulation to the feet without engorgement of the veins and small peripheral blood vessels. The occlusion was maintained for a period of 15 minutes (measured by a stopwatch), the temperature for the ten points being measured continously *ad seriatium*. Phase II was completed and Phase III, the *period of reactive hyperemia*, started by the sudden release of the pressure occluding cuffs, by means of valves. The temperatures were still measured for each part *ad seriatium* until a new baseline had been established.

Several aspects concerning this test require comment. For example, a baseline in Phase I with a maximum variation for any one of the ten parts of not more than 0.4°C. variation was used instead of an absolute baseline, (1) in order to avoid unduly prolonging the study, (2) because there is usually some fluctuation in the temperature of such parts as a part of the normal fluctuation in vascular blood volume, and (3) such a baseline proved to be satisfactory. A period of 15 minutes of occlusion was chosen, for, as shown by Lewis (6), in occlusions less than 15 minutes duration inadequate amounts of reactive hyperemia result, while occlusions of 20 minutes are associated with a great deal of discomfort with numbness, aching intense tingling and cramping. Occlusions lasting somewhat longer may result in nerve degeneration; occlusion for several hours will result in Volkmann's contractures.

The normal and trench foot subjects were studied at separate times or simultaneously, each in separate adjacent beds.

III. THE EXPERIMENTS

A. *The Occlusion-Reactive Hyperemia Test*

1. *Normal Subjects and Patients with Trench Foot:* The test was applied to 30 patients with Class I trench foot and 26 normal control subjects. These tests were repeated at least once on each subject for both feet, recording the temperature variations for four areas of each foot and the right middle finger tip of each hand. By using both feet, each foot was a check over the other and resulted in a study of 60 feet with trench foot and 52 normal feet.

The results are summarized by the records shown in Figures 1 through 9. In the normal subjects the typical reaction (Figure 6) consisted of a gradual drop in the temperature of the parts studied during the Phase I period of the test. During Phase II, or the 15 minute period of complete arrest of the circulation, the temperature of the parts decreased very slightly. After release of the circulation there was a rise in temperature (Phase III). This is called a "Normal Reaction."

The patients with trench foot showed quantitative differences. Their reactions were found to vary with the severity of their disease as follows: Patients with Class Ia disease were found to react as the normal control subjects or to show a very slightly greater rise in the temperature of the parts during Phase III of the test (Figure 7). They also tended, at times, to show a slightly greater and more rapid decrease in temperature of the parts during Phase II. The rise during Phase III rarely exceeded 1.5°C. Those patients of Class Ic, more severe disease, reacted in a fashion distinctly different from the normal subjects (Figure 9). They ran higher temperatures of the parts during Phase I, showed a greater and more rapid fall in temperature during Phase II, and decided increase in temperature during Phase III. The rise during Phase III usually was 3°C. or more. This rise tended

FIG. 1. This graph summarizes the temperature recordings for various portions of the feet and tip of the middle fingers in mild chronic trench foot and normal nude subjects covered only from the upper third of the thighs to the shoulders. The subjects remained recumbent at rest in bed in the control room at 20°C. (68°F.), humidity 50 to 65%, and rate of movement of room air less than 15 feet per minute.

B represents the temperature of the part just before occlusion of the circulation to the feet.

O represents the temperature of the part at the end of 15 minutes of occlusion of the circulation to the feet.

R represents the maximum temperature reached by the part after release of the circulation.

Thirty subjects (15 normal and 15 with Class I trench foot, 7 Class Ia, 3 Class Ib and 5 Class Ic). These studies represent single measurements on each subject during one week.

The mean values are shown within the columns. The extreme values are in the parenthesis above each column. This scheme of labeling is employed in the figures throughout.

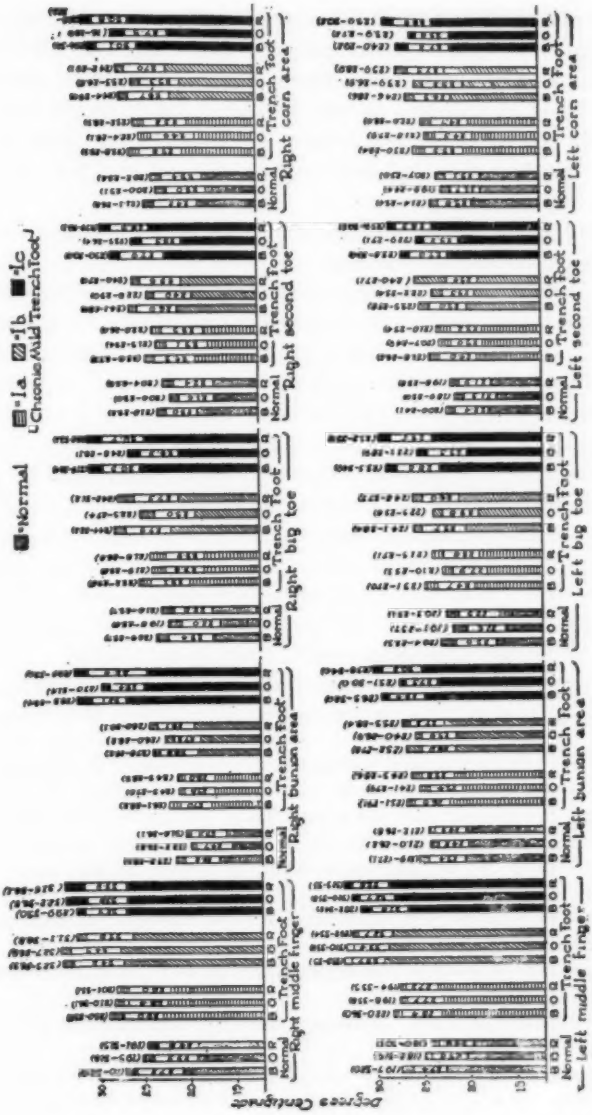
Normal
1a
1b
1c
Chronic Mild Trench Foot
Degrees Centigrade
Left middle finger
Left bunion area
Left big toe
Left second toe
Left corn area
Right middle finger
Right bunion area
Right big toe
Right second toe
Right corn area
Normal
Trench Foot
BOR

Fig. 1

to show a direct relationship to the degree and duration of the reactive hyperemia (*vide infra*). Those patients with Class Ib trench foot presented reactions and temperature curves which were between those of Class Ia and Ic. Of the 30 patients with trench foot, 16 showed the Class Ia reaction, 5 the Class Ib and 4 the Class Ic reactions. All 26 normal subjects had the normal or Class Ia type reaction.

Each individual patient or subject consistently presented the same type of reaction each time studied.

The differences in the reactions to the occlusion-reactive hyperemia test are illustrated by Figures 1 through 9 and Table 3. Figures 1 and 4 include the results for one week of study, while Figures 2 and 5 show the results for an entire series of observations over a period of several weeks. There are no differences in the nature of the reactions if tracings of an individual subject, tracings of a small group of subjects or tracings of a large series are examined. The reactions just mentioned were studied at a room temperature of 20°C. (68°F.). They were not different from some recorded at a room temperature of 18.3°C. (65°F.) (Figures 10 and 11). It can be seen from Table 3 that some of the temperature differences have mean values which are not statistically significant. This is most probably the result of the lack of a sufficiently large number of subjects in each series.

2. *Patients with Trench Foot and Patients with Psychoneurosis:* In order to further check the results just described, 24 of the above 30

FIG. 2. This graph summarizes the temperature recordings for various portions of the feet and tip of the middle fingers in mild chronic trench foot and normal nude subjects covered only from the upper third of the thighs to the shoulders. The subjects remained recumbent at rest in bed in the control room at 20°C. (68°F.), humidity 50 to 65%, and rate of movement of room air less than 15 feet per minute.

B represents the temperature determinations of the part just before occlusion of the circulation to the feet.

O represents the temperature of the part at the end of 15 minutes of occlusion of the circulation to the feet.

R represents the maximum temperature reached by the part after release of the circulation to the feet.

Eighty-five observations were made on 26 normal and 30 Class I trench foot subjects. The studies were conducted over a period of several weeks and represent 2 or more determinations on each subject.

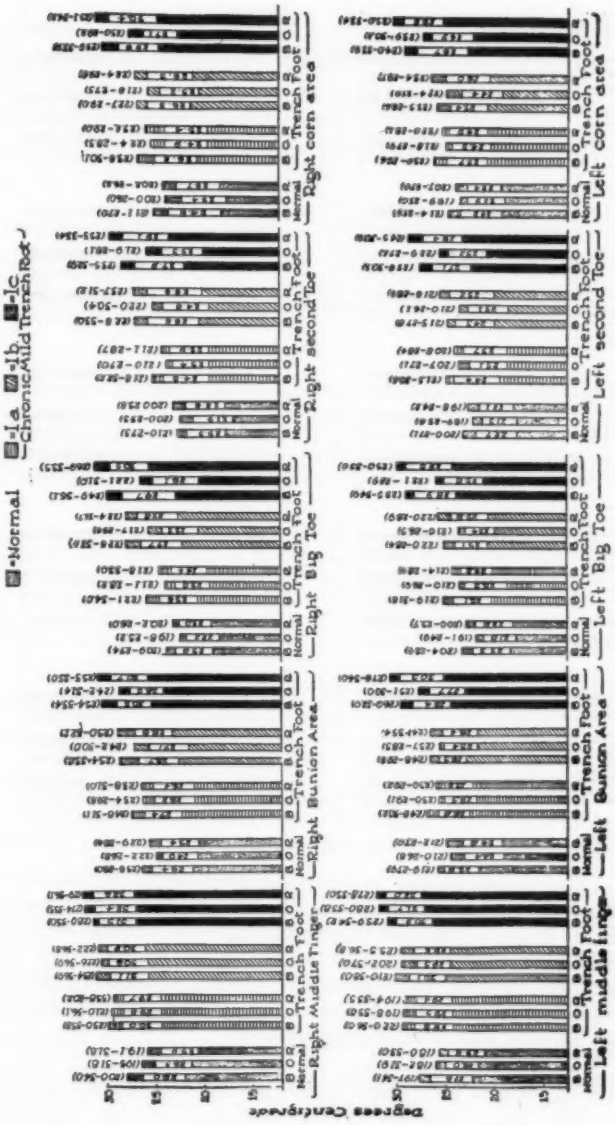
0-Normal
I-a
I-b
I-c
Chronic Mild Trench Foot
Degrees Centigrade
Left middle finger
Left Bunion Area
Left Big Toe
Left second Toe
Left corn area
Right Middle finger
Right Bunion Area
Right Big Toe
Right second Toe
Right corn area
Normal
Trench Foot

Fig. 2

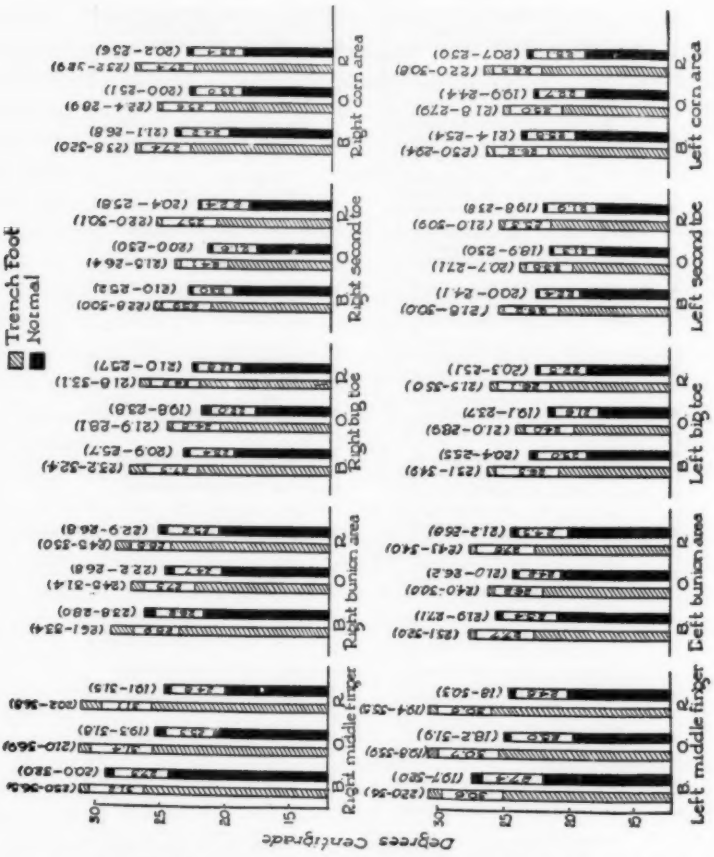

FIG. 3. This graph summarizes the temperatures recorded for various portions of the feet and the tip of the middle fingers of normal and Class I trench foot subjects shown in Figure 1. The prevailing conditions were identical to those in Figures 1 and 2.

This graph shows the differences between the normal and trench foot subjects, both as to absolute values in temperature and variations brought about by the three phases of the occlusion-reactive hyperemia test.

patients with trench foot were subjected simultaneously with 38 patients with psychoneurosis to the occlusion-reactive hyperemia

test applied to the right arm of each subject. A patient with each condition rested in separate adjacent beds. The experimental conditions were precisely the same as for the study of normal and trench foot subjects just described. Each trench foot patient was studied twice, with a different control patient with psycheneurosis.

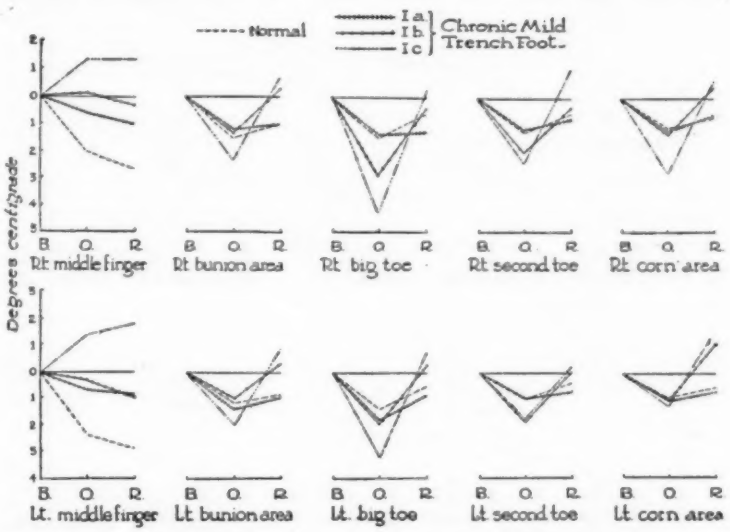

FIG. 4. This graph shows only the changes in temperature for the various parts during the occlusion-reactive hyperemia test in normal subjects and patients with trench foot, Class I (subgroups indicated). The zero temperature or reference value is that temperature noted just before occlusion of the circulation. The graph represents the changes in temperatures shown in Figure 1 without noting the absolute temperature values.

During these studies the finger and toe tip temperature variations were observed simultaneously during the occlusion-reactive hyperemia test. Temperature measurements were made on the: (1) tip or pad of the right index finger; (2) tip or pad of the right middle finger; (3) tip or pad of the right big toe; (4) tip or pad of the right second toe; and (5) tip or pad of the left middle finger of both patients with trench foot and those with psychoneurosis. During Phase II of the test, the circulation of the right arm and right leg were completely

occluded simultaneously by suddenly increasing the pressure in blood pressure cuffs applied to the right arm and right thigh above the elbow and knee, respectively.

The results are summarized by Figures 12 and 13 and 14. These Figures show a slight difference between the subjects with psychoneurosis and those with trench foot. Although these 38 patients

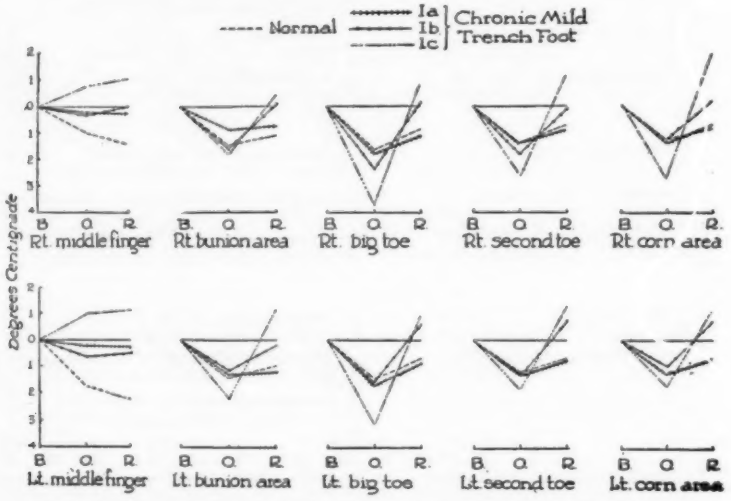

FIG. 5. This graph represents the changes in temperature of the various parts during the occlusion-reactive hyperemia test in normal subjects and patients with Class I trench foot. The zero or reference temperature is that recorded just before occlusion of the circulation to the feet. The graph represents the changes in temperature shown in Figure 2 without noting the absolute temperature values.

were supposed to have uncomplicated psychoneurosis, one had had trench foot in November, 1944, two had marked epidermophytosis of the feet with secondary infection, one was recuperating from the severe type of fungus infection of the feet contracted in the Southwest Pacific area ("Jungle Rot"), one was receiving atabrine, and several had received bullet wounds affecting the limbs (one of the right foot, one of the knee, one of the lumbar vertebrae, and one of the right hand). These wounds were essentially but not completely without

symptoms. Several of these subjects reacted to the occlusion-reactive hyperemia test as the Class Ia or Class Ib trench foot subjects. This

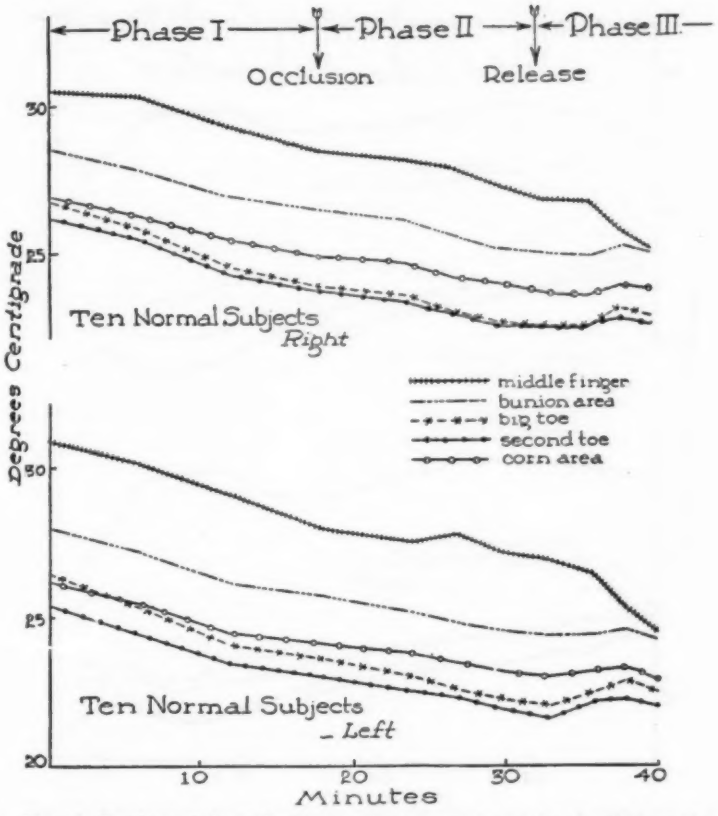

FIG. 6. Tracings of the occlusion-reactive hyperemia test for the right and left feet. Each tracing represents a composite of recordings for ten normal subjects. See text for description of occlusion-reactive hyperemia test and other details of the reactions.

was particularly true of those patients with the fungus infections of the feet and the patient who had had trench foot. None of these subjects, however, showed as marked a reaction as the Class Ic chronic

trench foot patient. All patients with psychoneurosis, regardless of the presence or absence of complications, were included in compiling

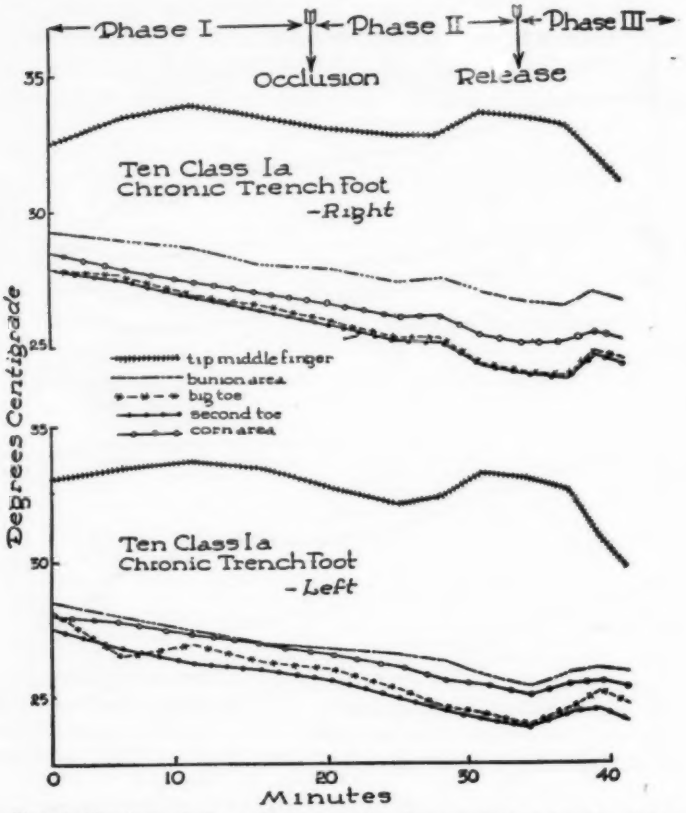

FIG. 7. Tracings of the occlusion-reactive hyperemia test for the right and left feet. Each tracing represents a composite of recordings for ten Class Ia trench foot subjects.

See text for description of occlusion-reactive hyperemia test and other details of the reaction.

Figures 13 and 14. If those patients with the complicating states were excluded, the differences between the patients with Ib or Ic trench foot and those with psychoneurosis would be greater. In the

construction of Figure 14, those patients with psychoneurosis who had the complications mentioned above were not used.

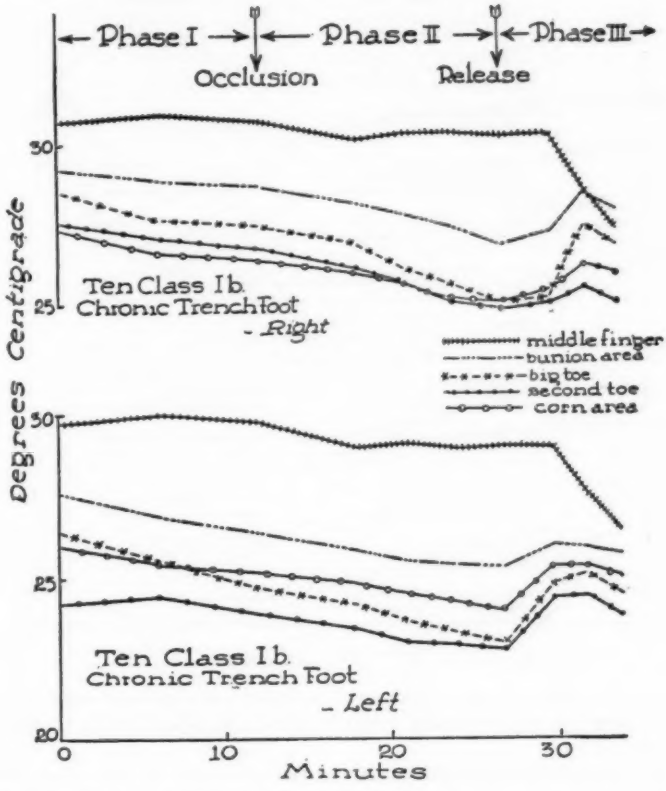

FIG. 8. Tracings of the occlusion-reactive hyperemia test for the right and left feet. Each tracing represents a composite of recordings for ten Class Ib trench foot subjects.

See text for description of occlusion-reactive hyperemia test and other details of the reaction.

In the finger tips of both the patients with trench foot and the patients with psychoneurosis there was a sharp drop after occlusion and a rise after release which did not attain the Phase I temperature

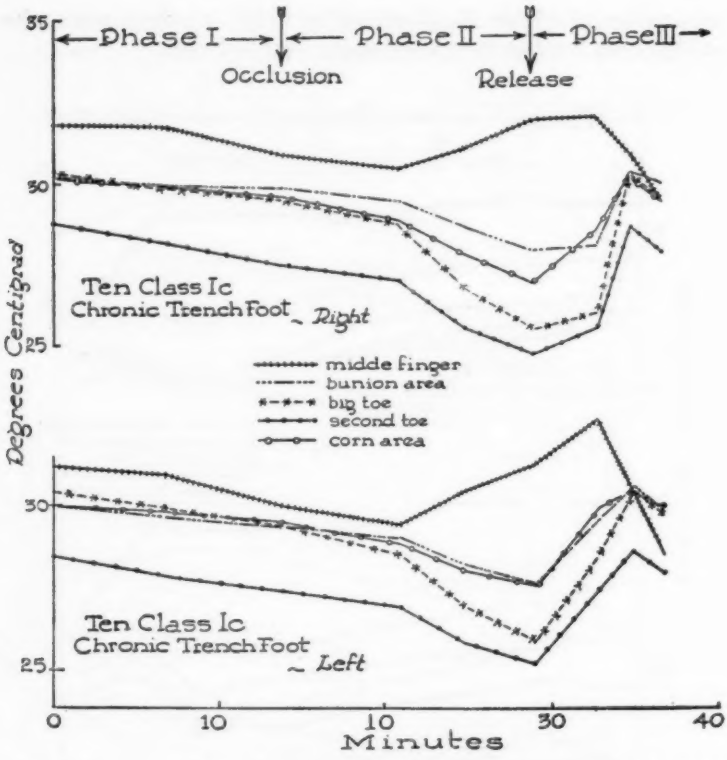

FIG. 9. Tracings of the occlusion-reactive hyperemia test for the right and left feet. Each tracing represents a composite of recordings for Class Ic trench foot subjects.

See text for description of occlusion-reactive hyperemia test and other details of the reactions.

levels. This marked drop is probably the result of the marked difference between the finger tip and room temperature, while in the toes, when this marked temperature gradient did not exist, the temperature

FIG. 10. This graph summarizes the temperature values for various portions of the feet and the tip of the middle fingers of 10 normal and 16 Class I trench foot (8 Class Ia, 3 Class Ib, and 5 Class Ic) subjects. All conditions prevailed as for Figures 1 and 2 except that the room was slightly colder, 18.3°C. (65°F.).

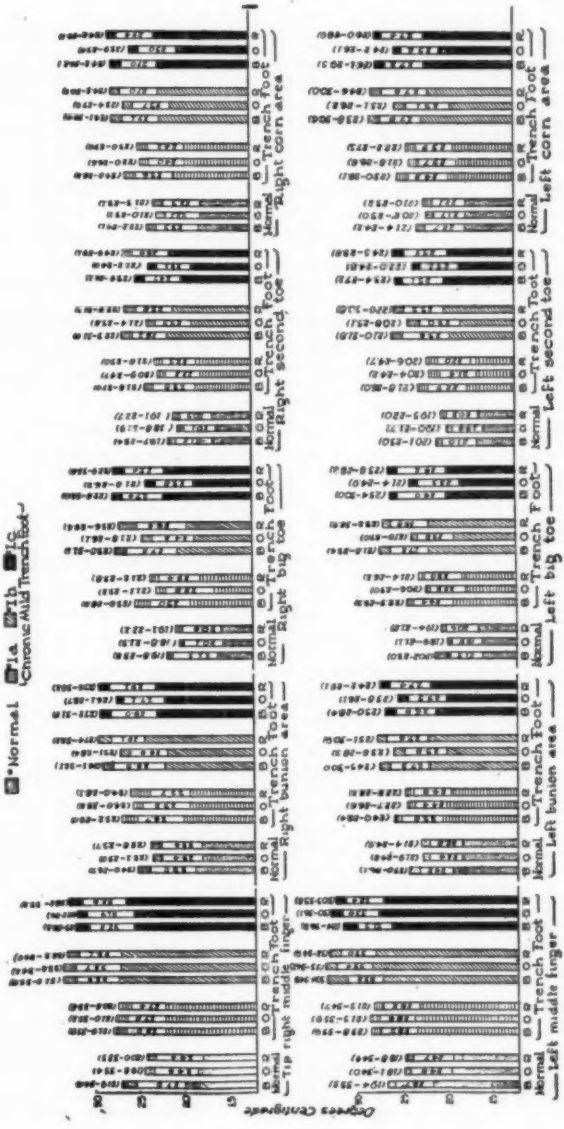
Normal
Chronic Mild Trench Foot
Normal
Trench Foot
Right middle finger
Right bunion area
Right big toe
Right second toe
Right corn area
Left middle finger
Left bunion area
Left big toe
Left second toe
Left corn area
Degrees Centigrade

Fig. 10

TABLE 3

The Change in Temperature of Various Portions of the Feet and Tip of the Right Middle Finger Following the Occlusion-Reactive Hyperemia Test

Statistical constants are shown for patients with mild chronic trench foot and normal subjects. All temperature values are in degrees centigrade.

RIGHT FOOT	MIDDLE FINGER				BUNION AREA				TIP BIG TOE				TIP SECOND TOE				CORN AREA			
Normal	Mean	Range	Standard deviation	Coefficient variation %	Mean	Range	Standard deviation	Coefficient variation %	Mean	Range	Standard deviation	Coefficient variation %	Mean	Range	Standard deviation	Coefficient variation %	Mean	Range	Standard deviation	Coefficient variation %
Temp. before occlusion	28.18 ±0.9	20 to 34	7.0 ±0.7	24.9 ±2.5	26.5 ±0.4	23.8 to 28	2.8 ±0.3	10.5 ±1.0	24.1 ±0.3	20.9 to 27.4	2.6 ±0.2	10.8 ±1.0	23.4 ±0.2	21 to 27.3	1.8 ±0.2	7.7 ±1.1	25.7 ±0.4	21.1 to 27	3.0 ±0.3	11.7 ±1.1
Temp. end of occlusion	26.5 ±0.9	19.3 to 31.8	6.6 ±0.6	24.9 ±2.5	25.0 ±0.3	22.2 to 26.8	2.0 ±0.2	8.0 ±0.8	22.3 ±0.3	19.8 to 25.2	2.6 ±0.2	11.7 ±1.1	22.2 ±0.2	20 to 25.3	1.6 ±0.2	7.2 ±0.7	23.6 ±0.4	20 to 26	2.9 ±0.3	12.3 ±1.2
Change in temp.	4.4 ±0.9	−6.0 to +.4	2.9 ±0.6	58.3 ±7.1	−1.5 ±0.1	−0.6 to −3.9	0.6 ±0.1	37.7 ±0.4	−1.8 ±0.1	−0.9 to −4.2	0.7 ±0.1	103.0 ±17.0	8.2 ±0.2	−0.5 to −3.1	1.4 ±0.1	17.1 ±1.6	−1.3 ±0.1	−0.5 to −1.8	0.7 ±.06	51.5 ±6.0
Max. temp. after release	26.0 ±0.9	+2.1 to 31.8	6.8 ±0.6	26.2 ±2.6	25.4 ±0.3	22.9 to 28.6	2.5 ±0.2	9.8 ±1.0	23.0 ±0.4	20.2 to 26	2.8 ±0.3	12.1 ±1.2	22.7 ±0.3	20 to 25.8	2.2 ±0.2	9.7 ±1.0	23.8 ±0.4	20.2 to 26.2	3.1 ±0.3	13.0 ±1.2
Change in temp. after release	3.4 ±0.3	−1.6 to +2.1	2.4 ±0.2	71.6 ±9.6	4.4 ±0.2	−0.4 to +2.8	1.5 ±0.1	33.9 ±3.2	+0.8 ±0.1	0 to −2.9	1.5 ±0.1	93.2 ±0.9	3.8 ±0.2	−0.1 to +1.6	1.2 ±0.1	31.9 ±3.3	+0.4 ±.04	−0.1 to +0.9	0.3 ±.03	84.9 ±12.5
LEFT FOOT																				
Temp. before occlusion	27.8 ±1.1	19.7 to 34.1	7.8 ±0.8	28.0 ±2.9	25.5 ±0.4	21.9 to 27.9	3.3 ±0.3	13.0 ±1.2	23.4 ±0.4	20.4 to 28.9	2.8 ±0.3	11.5 ±1.1	22.7 ±0.3	20 to 27.1	2.2 ±0.2	9.7 ±1.0	24.3 ±0.3	21.4 to 27.9	2.6 ±0.2	10.7 ±1.0
Temp. end of occlusion	26.0 ±1.1	18.2 to 31.9	8.2 ±0.8	31.5 ±3.3	24.6 ±0.3	21 to 26.8	2.1 ±0.2	8.6 ±0.8	21.8 ±0.3	19.1 to 24.9	2.1 ±0.2	9.6 ±0.9	21.6 ±0.2	18.9 to 23.8	1.6 ±0.2	7.4 ±0.7	23.7 ±0.4	19.9 to 25	3.1 ±0.3	13.0 ±1.2
Change in temp.	11.1 ±0.8	−6.5 to +3.1	4.7 ±0.5	42.0 ±4.1	0.6 ±0.1	−0.7 to −2.0	0.1 ±0.1	1.7 ±0.2	−1.6 ±0.2	−0.7 to −2.2	1.4 ±0.1	90.3 ±13.8	3.4 ±0.1	−0.3 to −3.3	1.8 ±0.1	26.3 ±2.6	−1.3 ±0.1	−0.4 to −3.7	1.3 ±0.1	51.9 ±5.3
Max. temp. after release	22.5 ±1.0	18 to 33	7.2 ±0.7	32.0 ±3.3	24.8 ±0.4	21.2 to 27	3.1 ±0.3	12.5 ±1.2	22.7 ±0.3	20 to 25.7	2.2 ±0.2	9.7 ±0.9	22.3 ±0.2	19.8 to 24.2	1.6 ±0.2	7.2 ±0.7	23.4 ±0.4	20.7 to 27	2.7 ±0.3	11.5 ±1.1
Change in temp. after release	3.6 ±0.2	−3.0 to +2.1	1.7 ±0.2	46.7 ±5.3	2.4 ±0.1	−0.2 to +1.8	0.8 ±0.1	30.6 ±2.9	+0.8 ±0.1	0 to +2.5	0.7 ±0.1	90.2 ±6.9	3.4 ±0.2	−0.2 to +1.8	1.4 ±0.1	41.8 ±4.6	2.9 ±0.1	−0.2 to +2.8	0.7 ±0.1	23.7 ±2.3

temp. after release	±0.2	+2.1	±0.2	±5.3	±0.1	+1.8	±0.1	±2.9	±0.1	+2.5	±0.1	±6.9	±0.2	+1.8	±0.1	±4.6	±0.1	+2.8	±0.1	±2.3

Trench foot

RIGHT FOOT																				
Temp. before occlusion	31.2 ±0.9	21.7 to 38.8	9.0 ±0.6	28.8 ±2.1	31.4 ±0.9	21.2 to 38.3	9.3 ±0.7	29.6 ±2.2	26.5 ±0.5	21.8 to 36.8	4.9 ±0.3	18.5 ±1.3	25.9 ±0.4	21.3 to 36	4.2 ±0.3	16.2 ±1.1	31.3 ±0.9	21 to 38	9.1 ±0.6	29.1 ±2.5
Temp. end of occlusion	25.9 ±0.5	20.2 to 32.8	5.5 ±0.4	21.2 ±2.07	26.2 ±0.6	20 to 32.3	5.7 ±0.4	21.8 ±1.6	24.2 ±0.3	20.8 to 31.1	3.5 ±0.2	14.5 ±1.2	23.9 ±0.4	20.8 to 29.2	3.7 ±0.3	15.4 ±1.5	30.4 ±1.0	20 to 38.8	10.3 ±0.7	34.0 ±2.5
Change in temp.	5.37 ±0.4	+0.2 to 8.9	4.0 ±0.3	74.5 ±7.5	5.8 ±0.5	−1.0 to 8.0	5.6 ±0.4	97.4 ±11.4	3.2 ±0.2	+0.5 to 8.2	2.5 ±0.2	81.8 ±8.6	1.8 ±0.2	−.2 to 4.7	1.8 ±0.1	102.8 ±7.8	11.0 ±0.5	−3.0 to +5.0	5.3 ±0.4	48.0 ±4.0
Max. temp. after release	28.2 ±0.6	21.3 to 34.1	6.4 ±0.4	22.7 ±1.6	28.4 ±0.8	20.8 to 34	7.7 ±0.5	27.1 ±2.0	25.8 ±0.5	21.8 to 34.9	4.7 ±0.3	18.2 ±1.3	25.3 ±0.4	21.4 to 32.1	4.3 ±0.3	17.0 ±1.1	30.4 ±0.9	20 to 37.9	9.5 ±0.7	31.3 ±2.4
Change in temp. after release	11.1 ±0.4	−0.2 to +7.2	4.1 ±0.3	36.9 ±2.9	2.5 ±0.2	0− to +7.2	2.1 ±0.1	83.3 ±8.9	.1.7 ±0.1	0 to +05.	1.3 ±0.8	76.9 ±7.9	1.2 ±0.3	0 to +4.6	2.9 ±0.2	239 ±17.3	5.0 ±0.2	−2.7 to +2.4	2.1 ±0.1	42.0 ±3.4

Patients with psychoneurosis

RIGHT FOOT																				
Temp. before occlusion	30.5 ±0.9	21.2 to 41.9	9.0 ±0.6	29.5 ±2.2	30.2 ±0.8	21.3 to 41.9	8.5 ±0.6	28.2 ±3.1	25.2 ±0.4	20.7 to 35.2	4.0 ±0.3	15.9 ±1.1	24.6 ±0.3	20.4 to 36.2	3.6 ±0.3	14.6 ±1.0	29.8 ±0.9	21.0 to 42.4	9.2 ±0.6	30.8 ±2.3
Temp. end of of occlusion	25.8 ±0.5	20.7 to 35.0	4.8 ±0.3	18.6 ±1.3	25.9 ±0.5	20.8 to 36.0	5.6 ±0.5	21.6 ±1.5	22.9 ±0.4	19.8 to 29.1	4.0 ±0.3	17.4 ±1.2	23.3 ±0.4	19.9 to 28.8	3.8 ±0.3	15.9 ±1.1	30.4 ±1.0	20.8 to 41.9	9.8 ±0.7	32.3 ±2.5
Change in temp.	7.6 ±0.6	−0.3 to 8.9	5.9 ±0.4	77.7 ±8.0	6.2 ±0.6	−0.1 to 8.2	5.8 ±0.4	81.0 ±8.5	2.0 ±0.2	−0.1 to −7.2	1.6 ±0.1	80.0 ±6.0	1.4 ±0.1	−0.2 to −7.4	1.0 ±0.1	71.8 ±7.1	5.9 ±0.6	−4.1 to +6.0	6.3 ±0.4	90.4 ±6.7
Max. temp. after release	29.0 ±0.7	21.6 to 40.0	7.2 ±0.5	24.8 ±1.9	29.2 ±0.7	21.5 to 40.9	7.6 ±0.5	24.3 ±1.8	25.8 ±0.3	21.0 to 36.9	3.4 ±0.2	24.1 ±1.7	24.7 ±0.3	21.0 to 35.0	3.4 ±0.2	13.8 ±1.0	27.8 ±0.8	21.6 to 40.8	8.4 ±0.6	28.2 ±3.2
Change in temp. after release	3.4 ±0.4	+0.1 to 8.0	4.0 ±0.3	91.9 ±10.4	5.3 ±0.5	−1.8 to +8.3	4.7 ±0.3	88.9 ±9.8	2.1 ±0.2	0 to +7.8	1.8 ±0.1	84.5 ±8.8	1.7 ±0.2	−0.1 to +6.2	1.7 ±0.1	7.1 ±0.5	1.8 ±0.1	−1.9 to +4.1	1.1 ±0.1	62.7 ±5.8

changes were not nearly so great. These differences in initial levels of the finger tips and toe tips is an expression of differences at least in their local circulations. The finger, with its known extensive vascularity and many glomi, would be expected to have a higher temperature.

These differences probably explain the marked rise in the temperature of the finger-tip after release with the only relatively slight rise

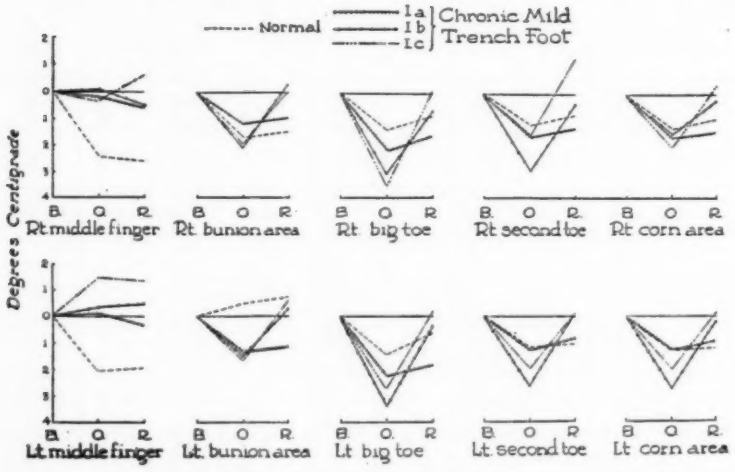

FIG. 11. This graph represents only the changes in temperature for the parts during the occlusion-reactive hyperemia test shown in Figure 10. The zero value or reference temperature is that noted just before occlusion of the circulation to the feet. Absolute values are not indicated.

in the temperatures of the toes. The qualitative nature of the reactions in the finger and toe tips were the same, however.

3. *Posterior Tibial Nerve Block:* Posterior tibial nerve block was employed to eliminate, for all practical purposes, nervous control of the vessels in the foot. Temporary blocking of the posterior tibial nerve with procaine at the lower border of the medial malleolus obtained a warm, dry foot with anesthesia of the sole in the cutaneous distribution of the medial and lateral plantar nerves, terminal branches of the posterior tibial nerve. This nerve block removed vasoconstrictor influences initiated by psychogenic, reflex and environmental

stimuli. Thus an opportunity was provided for study of circulatory responses uninfluenced by nervous control. Vasospasm was eliminated, and almost complete potential blood flow to the plantar portions of the foot was attained and evaluated. Although posterior tibial nerve block falls short of complete obliteration of nervous

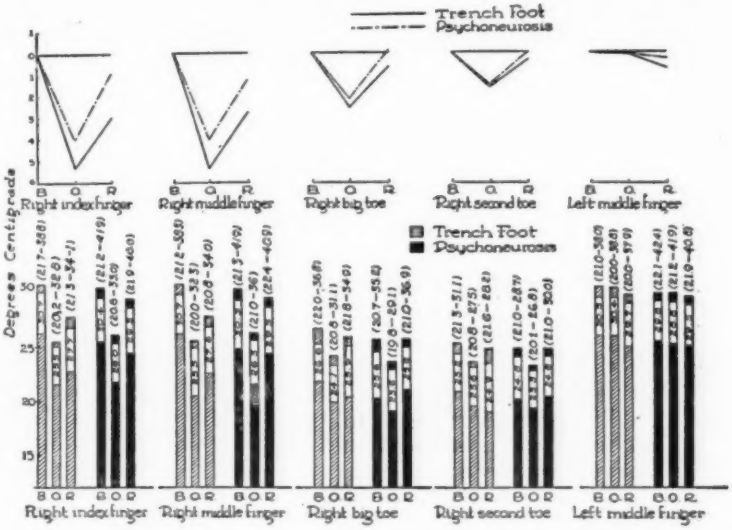

FIG. 12. This graph summarizes the temperature observations made before, during occlusion and after release of the circulation of the right foot and right hand. Trench foot and psychoneurotic subjects are compared. The graph shows both the absolute values (lower column graph) and the changes in temperature only (upper line graphs). Consult the text for details.

There were 29 patients of whom 18 were psychoneurotic and 11 had trench foot. They were studied during a single week.

vasoconstriction and is inferior to spinal anesthesia or lumbar sympathetic block for that purpose, the ease and simplicity of this procedure offset the failure to obtain complete removal of all vasoconstriction. Lumbar sympathetic block has the additional advantage of producing no anesthesia in the foot and no motor paralysis in some of the intrinsic muscles in the sole of the foot. The features of anesthesia of the sole of the foot in the distribution of the medial and lateral plantar nerves

and paralysis of some of the intrinsic muscles in the sole of the foot interfere slightly with walking for the duration of action of the anesthetic agent used in blocking. Simultaneous bilateral blocking is therefore not advised.

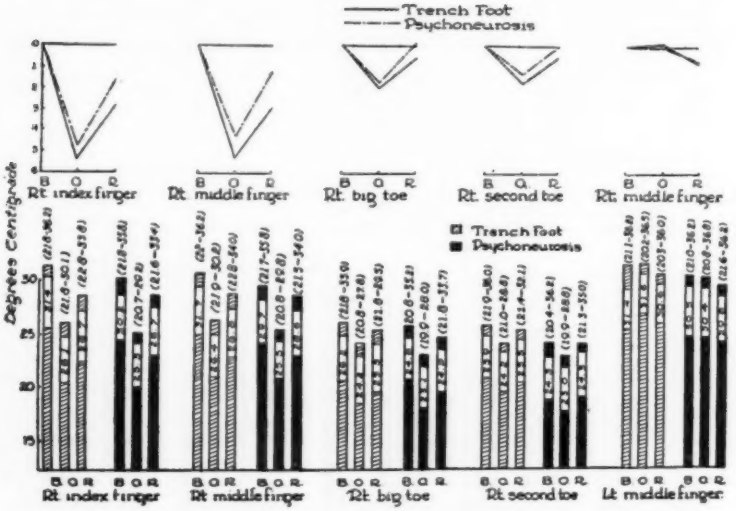

FIG. 13. This graph summarizes the temperature observations made before during occlusion and after release of the circulation of the right foot and right hand. The graph shows both the absolute values (lower column graph) and the changes in temperature only (upper line graphs). Consult the text for details. Trench foot and psychoneurotic subjects are compared.

There were 76 observations upon 62 subjects of whom 38 had psychoneurosis and 24 had trench foot. They were studied over a period of several weeks, most of them being studied at least twice.

The method used in producing the posterior tibial nerve block: The skin was prepared with a suitable antiseptic (denatured 70 per cent alcohol). A point was selected at the junction of the anterior third and posterior two thirds of a line drawn from the center of the medial malleolus to the junction of the plantar and posterior point of the heel. A wheal was produced with 1 cc. of 2 per cent procaine at this point with a small syringe and 24 gauge hypodermic needle.

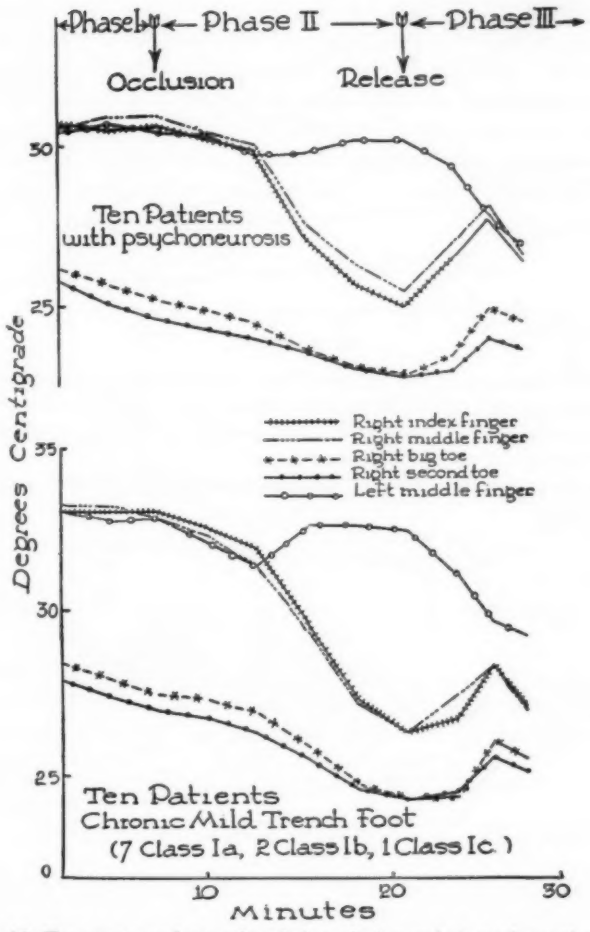

FIG. 14. Temperature observations before, during and after release of occlusion of the circulation of both upper and lower right extremities. These tracings represent a composite of the curves of 10 psychoneurotic patients and 10 trench foot patients.

A 19 gauge needle was then introduced perpendicularly through the anesthetized skin down to the bone and 10 cc. of 2 per cent procaine

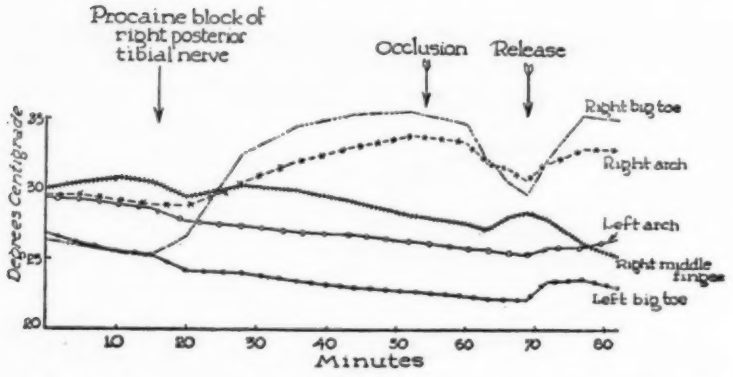

FIG. 15. Temperature observations of the combined effects of posterior tibial nerve block and the occlusion-reactive hyperemia test. Only the right posterior tibial nerve was blocked in each case. The occlusion-reactive hyperemia test was applied to both feet, not to the hands.

These curves represent the composite recordings of 10 normal male subjects.

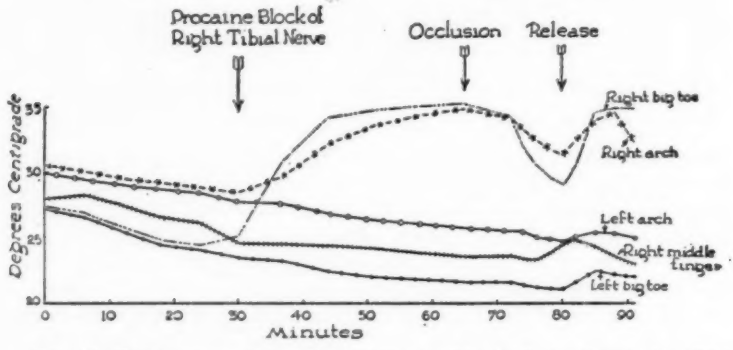

FIG. 16. Temperature observations of the combined effects of posterior tibial nefve block and the occlusion-reactive hyperemia test. Only the right posterior tibial nerve was blocked in each case. The occlusion-reactive hyperemia test was applied to both feet, not to the hands.

These curves represent the composite recordings of 10 normal female subjects.

was injected. Within 15 to 30 minutes the maximum effect was reached as measured by (1) anesthesia of the sole of the foot in the cutaneous distribution of the medial and lateral plantar nerves; (2)

a definite rise in temperature and (3) a cessation of local sweating. The full effect was maintained for approximately one hour with a gradual decline during the next hour.

Application of posterior tibial nerve block to circulatory studies: Studies similar to those described above were conducted upon 12 subjects with Class Ia trench foot, 12 patients with psychoneurosis, 19 male normal subjects and 19 normal females. The only new

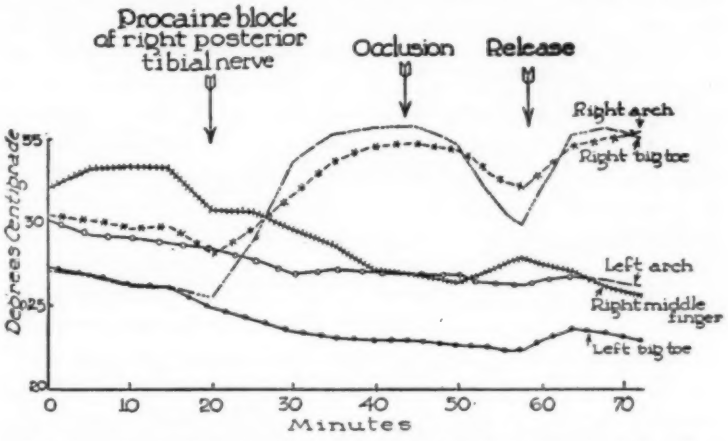

FIG. 17. Temperature observations of the combined effects of posterior tibial nerve block and the occlusion-reactive hyperemia test. Only the right posterior tibial nerve was blocked in each case. The occlusion-reactive hyperemia test was applied to both feet, not to the hands.

These curves represent the composite recordings of 10 psychoneurotic subjects.

factor added to the occlusion-reactive hyperemia test was the introduction of unilateral posterior tibial nerve block. A condensation graph of the results in 10 subjects was made in each series. The Class Ia trench foot cases closely paralleled the normal controls. (Figures 15, 16, 17 and 18). The reactions in the female showed no distinctive differences from those in the males except that it required from 10 to 15 minutes longer for them to reach thermal stability. The curves of the normal subjects and patients with psychoneurosis and trench foot showed close similarity. The curve for the right middle finger in the psychoneurotic showed a high initial temperature,

reaching maximum temperature of 33.4°C. during the first ten minutes in the constant temperature room but fell shortly afterwards to 30.7°C. This might be an expression of vasomotor instability. Apparently a very high degree of vasodilatation was obtained with blocks because the peak temperature reached after block was not exceeded by the combined effects of block and reactive hyperemia. The fact that the blocking of one extremity had very little influence over the other is also interesting and important, for then the unblocked extremity

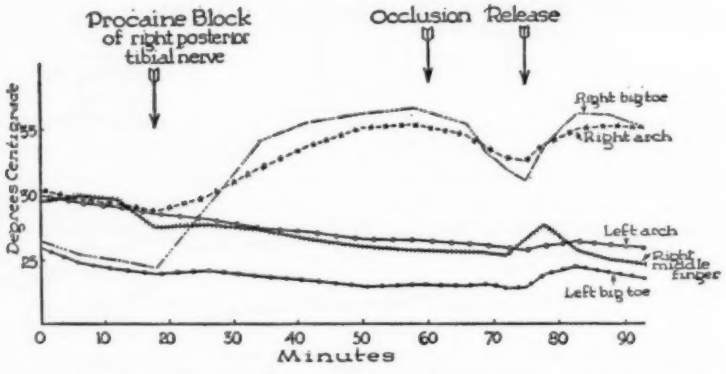

FIG. 18. Temperature observations of the combined effects of posterior tibia nerve block and the occlusion-reactive hyperemia test. Only the right posterior tibial nerve was blocked in each case. The occlusion-reactive hyperemia test was applied to both feet, not to the hands.

These curves represent the composite recordings of 10 Class Ia trench foot subjects.

served as a good control for the blocked one. The slight rise in the temperature of the finger simultaneously with the fall in temperature of the lower extremity was quite constant throughout these studies. There seemed to be an inverse ratio between the degree of fall in temperature of the part occluded and the degree of rise in temperature of the hand with its circulation intact. An adequate explanation for this phenomenon is still wanting. There was a distinct fall in temperature following occlusion in the foot with the nerve block. Simultaneously no fall following occlusion was noted in the foot without nerve block. The temperature before occlusion of 36.4°C. in the trench

foot patients in the right great toe with the nerve block, fell to 30.6°C. during occlusion of the circulation to the toe, whereas in the left big toe without nerve block the temperature was 23.0°C. at the onset of occlusion. The temperature fell only 0.5°C, .that is, to 22.5°C. Apparently the higher the temperature at the beginning of occlusion and the more profound the vasodilatation, the greater the fall in temperature following occlusion, and the greater the rise during the phase of reactive hyperemia.

An interesting physiologic fact is here demonstrated. The total number of degrees rise following nerve block in the right great toe of the Class Ia trench foot was 12.2°C. This maximum was not exceeded in spite of the additional vasodilating influence of reactive hyperemia, indicating that the removal of neurogenic vasomotor tone had resulted in a maximum temperature rise in the right great toe. In the foot without nerve block the temperature rise in the great toe following release of occlusion was only 1.7°C. or only about one sixth the rise obtained in the foot with nerve block. Evidently reactive hyperemia of 15 minutes is not a very adequate method by which to obtain a high degree of vasodilatation and does not adequately demonstrate the full potentialities of the local circulation. The advantage, however, of reactive hyperemia as a test for disease in trench foot over vasodilatation produced by interruption of nervous impulses lies in the fact that this type of reaction occurs under integrating influences of the existing physiologic factors concerned with controlling the circulation of a part. A less artificial situation exists in the unblocked extremity. Therefore conditions regulating vessel caliber can be integrated in a fashion more closely resembling that existing in the normals when reactive hyperemia is employed without nerve block.

There is a similarity between the curves of normal males, females, psychoneurotics and Class Ia trench foot subjects. The tendency of the female subjects to take considerably longer than the males to reach stabilized temperatures warrants explanation. Motivated by modesty, these subjects refused to strip nude. They always wore their underclothing and frequently did not remove their khaki shirts. The importance of stripping the subjects nude has been stressed (*vide supra*). It is a known fact that coverings and warming of the

trunk will raise the temperature of the extremities, a phenomenon that most probably occurred in the female subjects and resulted in warmer hands and feet than in the male subjects.

4. *Patients with Miscellaneous Vascular Diseases:* Eight subjects with other types of abnormalities were subjected to the occlusion-reactive hyperemia test. They were: one with acute alcoholism, one with frostbite, one with uninjected varicose veins, five with severe (Class III) trench foot. The subjects with acute alcoholism and frostbite reacted in a fashion similar to the patients with Class Ib or Ic trench foot. The patient with varicose veins reacted in a normal fashion. The patients with Class III trench foot had no toes and in some instances had lost the distal portions of their metatarsals. With only two exceptions the terminal portions of the involved parts had infected draining ulcers. These lesions made it difficult to apply the thermocouples properly and, of course, toes could not be studied. The reactions noted for areas in the region of the distal ends of the metatarsals were difficult to interpret and compare with the reactions found in patients with intact feet because of the difference in tissue mass between the two groups and the presence of infected ulcers. As a matter of fact, the reactions found were similar to those described for Class Ia, Ib and Ic trench foot.

B. *Miscellaneous Quasi-objective Tests*

While performing the occlusion-reactive hyperemia tests, certain observations of a none too exact and objective nature were made. These extra observations required relatively little effort. Each is discussed below.

1. *So-called "state of vascular tone":* Naide (8 and 9) claims that by measuring the temperature of the pad of the tip of the middle finger of a nude, fasting subject covered only with a cotton sheet and resting in bed in a room at 20°C. (68°F.) for 15 minutes he can determine the state of the subjects vascular tone. In order to apply Naide's observations in our study, his procedure was followed in nearly all of the normal and abnormal subjects studied.

The results of the test of Naide are summarized by Table 4 and Figure 19. Only 10.3 per cent of the normal male subjects and only 15.8 per cent of the females had temperatures below 25°C. Seven and

TABLE 4

Temperature of the Tip of the Right and Left Middle Finger at the End of 15 Minutes Rest in a Room at 20°C. (68°F.) of Patients with Mild Chronic Trench Foot and Control Subjects

	NORMALS				TRENCH FOOT						ALL GROUPS		PSYCHO-NEUROTIC		MISCELLANEOUS	
	Male		Female		1a		1b		1c							
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Number of Subjects	39	16	19		28	17	6	6	7	7	41	30	53	41	9	1
Mean	30.39	29.37	29.09		29.63	30.53	30.38	31.63	31.34	30.78	30.45	30.92	30.81	30.60	28.14	23.6
Max.	35.8	34.2	34.8		37.2	36.5	38.4	38	35.3	35.4	37.2	38	41.9	42.8	32.2	23.6
Min.	22.5	22	22.2		22	23.8	1.1	22	22.8	24.2	21.1	22	21.8	21.2	24	23.6
Number with temp. below 25°C.	6		3		8		8		2			18		18		3
Number with temp. above 25°C.	52		16		104		24		36			164		115		8
% Below 25°C.	10.3		15.8		7.1		25.0		5.3			9.9		13.5		27.3

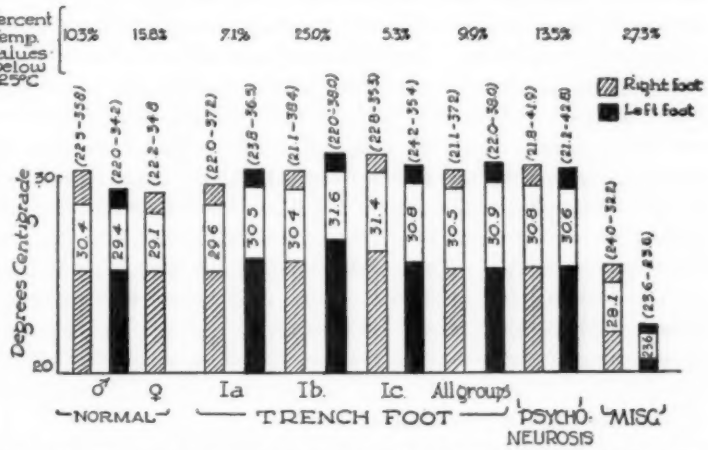

FIG. 19. This graph summarizes the observations of "Vascular Tone" (Naide[8,9]), the temperatures being of the tip of the right and left middle fingers of the subjects at the end of 15 minutes' rest in a room temperature of 20°C. (68°F.). See text for details.

one tenths per cent of the patients with Class Ia trench foot, 25 per cent of the Class Ib, 5.3 per cent of Class Ic or 9.9 per cent of the total trench foot group had temperatures of the finger tip below 25°C. There were 13.5 per cent of the patients with psychoneurosis and 27.3 per cent of the miscellaneous group with temperatures below 25°C. Using Naide's criteria, it was found, therefore, that vascular tone among the trench foot patients was slightly less than that among the normal and psychoneurotic subjects and definitely less than found in the miscellaneous group of patients. In Naide's normal subjects over 50 per cent were found to be vasospastic, while in normal subjects in this study only slightly more than 10 per cent were found to be vasospastic. Since these studies were performed in New Orleans in the summer time, it is possible that climatic conditions may explain these differences. It is felt, however, that before Naide's test can be accepted for general use such variables as climate should be investigated. In any case, this test for vasomotor tone proved to be of little value in the study of patients with mild chronic trench foot.

2. *Skin Color:* Because of the variations in skin color in trench foot during various stages of the disease an attempt was made to quantitate the color phenomena noted during the three phases of the occlusion-reactive hyperemia test. Lewis' color charts (10) were employed for quantitating the colors in some of the normal and trench foot subjects. Near the end of Phase I, that is, just before occlusion of the circulation, and three minutes before the end of Phase II or near the end of the period of occlusion, the colors were estimated. Since there were marked variations in the nature of the skin color over various portions of the feet, only the color of the toes and dorsal areas of the feet near the toes was studied. These areas were chosen since they are frequently involved in trench foot. Color readings were therefore obtained for the subject resting horizontally in bed in a constant temperature room before his circulation was disturbed and another reading was obtained after 12 minutes of complete arrest of the circulation, before it had been released again.

The results are summarized by Tables 5, 6, 7, and 8. It can be seen from the Tables that the feet of the *normal subjects*, during the resting period, had a pale pink color with an occasional one showing a bluish hue to the background of color. After 12 minutes of complete arrest of

TABLE 5

Quasi Objective Observations on 18 Normal Subjects

TABLE 5

Quasi Objective Observations on 18 Normal Subjects

The studies are concerned with measurements of the rate of refilling of pressure emptied skin vessels. The flush of reactive hyperemia, and variation in skin color measured by Lewis color chart.

SUBJECT	AGE	RATE OF REFILLING OF PRESSURE EMPTIED SKIN VESSELS (SECONDS)						FLUSH OF REACTIVE HYPEREMIA				SKIN COLOR	
		At start of study		After 15 min. at 20°C.		At end of exper.		First appearance	Appearance of max. flush	Degree		Before occlusion	12 Min. after occlusion
		Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	(seconds)	(seconds)	Rt.	Lt.		
W.S.H.	26	3.8	3.0	6.0	6.0			4.3	45.2	3 +	2 +	i	i (K blotches)
S.A.	25	3.0	2.8	4.0	3.5	8.0	7.0	9.5	57.2	2 +	2 +	K (slight pink tint)	j (i blotches)
B.J.J.		3.0	3.0	5.0	5.0		7.4	8.8	57.3	1 +	1 +	K (slight pink tint)	j
D.T.O.	24	8.5	8.5			14.0	15.5	9.0	38.0	2 +	2 +	K (slight pink tint)	K (j blotches) (purple tint)
G.S.	23	5.0	5.0	10.0	11.5	19.0	20.0	10.8	60.4	2 +	2 +	j	K
B.H.	25	4.0	4.0	6.0	6.0	5.8	6.0	5.0	45.0	3 +	3 +	K (pink tint)	K
G.H.	23	3.8	3.5	5.2	5.0	12.8	10.2	5.0	32.2	3 +	3 +	K (pink tint)	K (j blotches)
C.E.	23	5.0	5.0	10.2	10.0	15.0	14.8	15 0	58.0	1 +	1 +	K (pink tint)	K
F.W.	22	2.2	2.0	2.5	2.5	6.0	9.8	8.8	47.6	1 +	1 +	K (pink tint)	r-j (K blotches) 1-K (pink tint)
L.S.	23	4.5	4.5	7.5	8.0	8.0	10.0	12.0	56.0	2 +	1 +	K	K
A.B.	23	2.0	3.0	4.0	3.5	13.0	13.5	9.0	62.2	2 +	1 +	K (slight pink tint)	K
H.G.	24	3.0	3.0	6.0	5.0	8.2	10.5	7.0	53.0	2 +	1 +	i (slight pink tint)	i (slight purple tint)
H.E.	23	10.0	8.0	11.0	10.5	11.0	10.2	9.0	61.0	3 +	2 +		K (i tint)
V.M.	25	6.0	6.5	15.8	13.0	15.0	14.4	12.8	49.6	1 +	1 +	j (slight purple tint)	j (slight purple tint)
W.S.	26	4.0	4.0	5.4	8.0	8.0	9.0	9.0	49.0	3 +	2 +	K (pink tint)	j (g tint)
H.C.	23	5.0	5.0	5.0	5.0	7.0	7.0	11.0	50.0	1 +	1 +	j (very slight pink tint)	j (i blotches)
F.J.	24	6.0	6.0	6.9	7.0	12.0	10.5	9.0	32.4	3 +	2 +	i (pink tint)	j (i blotches)
H.R.	22	4.8	4.8	7.5	8.0	15.0	12.0	8.0	56.0	3 +	2 +	j (pink tint)	j (purple tint)
Mean.....		4.6	4.5	6.9	9.1	11.1	11.2	9.1	50.6	2.1+	1.7+		
Max.....		10.0	8.5	11.0	13.0	19.0	20.0	15.0	62.2	3 +	3 +		
Min.....		2.0	2.0	2.5	2.5	5.8	6.0	4.3	32.2	1 +	1 +		

TABLE 6

Quasi Objective Observations on 25 Class Ia Trench Foot Subjects

These studies are concerned with the same features as in Table 5.

SUBJECT	AGE	RATE OF REFILLING OF PRESSURE EMPTIED SKIN VESSELS (SECONDS)						FLUSH OF REACTIVE HYPEREMIA					SKIN COLOR	
		At start of study		After 15 min. at 20°C.		At end of exper.		Reactive Hyperemia app. of flush	App. of max. flush	Degree of flush			Before occlusion	12 min. after occlusion
		Rt.	Lt.	Rt.	Lt.	Rt.	Lt.			Rt.		Lt.		
T.R.	19	10.0	8.0	17.0	10.0			11.0	46.5	3	+	2 +	j (pink tint)	r-j (h blotches) l-j
K.B.	34	5.0	5.0	10.0	8.0			6.0	30.0	2	+	1 +	j	K (small j blotches)
L.L.	19	5.0	5.0	8.5	6.5			6.0	51.6	2	+	2 +	j (pink tint)	r-i l-j
Mc.E.	30	7.5	7.5	9.0	9.0	5.5	9.0	7.0	55.0	4	+	3 +	j (pink tint)	i (j blotches)
C.C.	22	5.0	5.0	6.5	5.0	10.0	9.2	7.0	43.6	3	+	3 +	j (pink tint)	j (i tint)
J.H.	25	3.5	3.5	10.0	9.0	10.0	10.0	13.4	62.0	3	+	3 +	K (slight pink tint)	r-i l-i
G.C.	23	5.0	5.0	8.0	11.0	19.0	17.0	12.5	62.0	3	+	3 +	j (pink tint)	i (j blotches)
W.W.	33	5.0	5.0	7.5	7.0	7.0	6.5	6.0	55.0	5	+	4 +	K (pink tint slight purple tint r big toe)	K (purple tint)
W.W.	33	5.5	5.5	8.0	8.0	8.5	9.0	9.0	53.0	3	+	3 +	K (pink tint)	j (purple tint)
J.H.	25	8.0	12.0	9.0	14.5	10.0	22.0	22.2	110.0	4	+	3 +	j (pink tint purple tint on r big toe only)	j (purple tint on big toes only)
J.H.	25	10.5	12.5	9.5	14.0	13.5	15.0	10.4	65.0	4	+	3 +	j (pink tint purple tint on r big toe)	j (purple tint K blotches)
M.E.	25	5.0	5.0	7.0	6.5	7.5	6.0	10.0	46.8	4	+	3 +	K (pink tint)	j (purple tint)
M.E.	25	4.5	4.5	8.0	7.5	10.0	9.0	10.5	44.6				K (pink tint)	j (purple tint)
L.J.	19	6.2	5.5	9.5	9.0	10.0	10.5	8.0	60.0	6	+	5 +	j (2 red tint)	j (h tint on both big toes)
H.C.	34	4.5	4.0	8.0	8.0	10.9	9.5	7.5	46.5	5	+	5 +	j (pink tint)	j (purple tint)
H.C.	34	8.0	6.0	8.0	11.0	10.0	12.0	11.0	55.0	2	+	2 +	K (slight pink tint)	j (slight purple tint)

H.C.	34	5.5	5.5	9.0	8.0	9.0	10.0	8.5	52.5	3	+	2	+	K (pink tint)	j
S.C.	19	8.5	8.0	15.0	15.0	15.0	15.0	8.8	76.8	3	+	2	+	K (purple tint on big toes only)	K (slight purple tint)
S.C.	19	4.0	6.0	5.5	6.5	12.0	19.0	14.0	60.0	2	+	2	+	K (mostly pink tint slight purple tint both big toes)	K (slight purple tint on big toes)
B.G.	21	5.0	5.0	7.0	6.0	9.0	9.0	10.0	60.0	4	+	3	+	j (reddish purple tint)	j (h blotches)
B.G.	21	4.0	4.0	4.0	4.0	6.0	6.0	11.0	56.0	4	+	3	+	j (pink tint)	r-g(j blotches) l-i (j blotches)
S.H.	20	10.0	10.0	19.0	18.0	16.0	18.0	13.0	127.0	4	+	3	+	K (g blotches on big toes only)	K (g blotches)
S.H.	20	9.0	9.0	16.0	18.0	15.0	18.0	15.0	68.5	4	+	3	+	K (slight purple tint)	j (slight purple tint K blotches)
C.J.	36	5.0	5.0	7.0	7.0	8.5	10.0	6.0	39.0	2	+	2	+	K (pink tint)	j (slight purple tint)
C.J.	36	4.0	4.0	7.0	7.0	9.0	10.0	8.0	52.8	2	+	1	+	K (pink tint)	K (slight purple tint on r big toe only)
Mean.....		6.1	6.2	9.3	9.3	10.5	11.8	10.1	59.2	3.4	+	2.8	+		
Max.....		10.5	12.5	19.0	18.0	19.0	22.0	22.2	127.0	6	+	5	+		
Min.....		3.5	3.5	4.0	4.0	5.5	6.0	6.0	30.0	2	+	1	+		

TABLE 7

Quasi Objective Observations on 7 Class 1b Trench Foot Subjects

These studies are concerned with the same features as in Table 5.

SUBJECT	AGE	RATE OF REFILLING OF PRESSURE EMPTIED SKIN VESSELS (SECONDS)						FLUSH OF REACTIVE HYPEREMIA				SKIN COLOR	
		At start of study		After 15 min. at 20°C.		At end of exper.		Reactive Hyperemia app. of flush	App. of max. flush	Degree of flush		Before occlusion	12 min. after occlusion
		Rt.	Lt.	Rt.	Lt.	Rt.	Lt.			Rt.	Lt.		
N.L.	34	2.5	3.5	3.2	5.0	5.4	6.5	5.0	45.2	6 +	4 +	K (pink tint)	j (h blotches)
C.E.	25	13.0	9.0	13.0	9.0	10.0	10.0	11.0	53.5	2 +	2 +	j (pink tint)	j (g tint)
D.J.	22	10.0	6.0	10.0	6.0			11.0	75.0	4 +	3 +	r-i (h blotches big toe) l-i (slight pink tint)	K (i blotches)
C.H.	25	5.0	5.0	7.0	6.5	7.0	7.0	8.0	41.4	4 +	4 +	j (pink tint)	i (purple blotches)
D.J.	22	5.0	4.0	5.0	4.5	8.6	5.0	8.4	51.0	5 +	4 +	K (pink tint)	K (purple tint, j blotches)
D.J.	22	3.0	3.5	8.0	8.0	11.0	9.0	9.0	60.0	3 +	2 +	j (pink tint)	j (H blotches)
D.J.	22	3.0	2.5	4.0	3.0	12.8	11.5	9.2	41.2	2 +	2 +	K (pink tint)	K (slight i tint)
Mean.....		5.9	4.8	7.2	6.0	9.1	8.2	8.8	52.5	3.7+	3.0+		
Max.....		13.0	9.0	13.0	9.0	10.0	11.5	11.0	75.0	6 +	4 +		
		2.5	2.5	3.2	3.0	5.4	6.0	5.0	40.0	2 +	2 +		

TABLE 8

Quasi Objective Observations on 4 Class 1c Trench Foot Subjects

These studies are concerned with the same features as in Table 5.

SUBJECT	AGE	RATE OF REFILLING OF PRESSURE EMPTIED SKIN VESSELS (SECONDS)						FLUSH OF REACTIVE HYPEREMIA				SKIN COLOR	
		At start of study		After 15 min. at 20°C.		At end of exper.		Reactive Hyperemia app. of flush	App. of max. flush	Degree of flush		Before occlusion	12 min. after occlusion
		Rt.	Lt.	Rt.	Lt.	Rt.	Lt.			Rt.	Lt.		
A.G.	29	4.0	4.0			4.0	4.0	6.2	53.6	4 +	3 +	j (g tint)	h (j blotches)
F.W.	19	2.0	1.5	2.0	2.0	4.0	3.0	7.0	36.2	3 +	2 +	V	g (j blotches)
D.H.	22	4.0	4.0	6.0	7.0	7.0	6.8	6.8	70.0	4 +	3 +	K (pink tint)	r-K (i blotches)
A.J.	34	6.0	5.0	8.0	6.0	7.0	7.0	6.0	67.5	3 +	2 +	K (very slight pink tint)	V (i blotches on big toes)
Mean.....		4.0	3.6	5.3	5.0	5.5	5.2	6.5	56.8	3.5+	2.5+		
Max.....		6.0	5.0	8.0	7.0	7.0	7.0	7.0	70.0	4 +	3 +		
Min.....		2.0	1.5	2.0	2.0	4.0	3.0	6.0	36.2	3 +	2 +		

the circulation, the bluish background increased in intensity with the associated development of marked mottling (Bier's spots). Some of the blotches were almost purple in color, while others were white or apparently devoid of blood. The white blotches suggested islands of marked vasoconstriction. These areas of white blotches would often expand slowly centrifugally. The patients with *mild chronic trench foot*, Class Ia, tended to resemble the normal subjects except that there was, in many cases, decidedly more cyanosis, or blueness, to the background color both before and during occlusion of the circulation. The subjects with more advanced disease, Class Ic, showed much more evidence of cyanosis, even color values of *i* and *h* (10) were encountered before occlusion. Occasionally there was a reddish purple color to the background, a *V* color, for example. During the occlusion, the cyanotic color became much more intense than in the normal. The skin color findings in the moderately severe trench foot patients, Class Ib, were essentially in between that for the Class Ia and Ic patients.

In several instances, the deep purple which developed in the toes, usually in the areas where a previous mass of superficial tissue had undergone gangrenous changes, was very slowly displaced by the hyperemia following release of the circulation. It required, at times, as long as 180 seconds for the medical aspect of a big toe to become hyperemic or for the cyanosis to be completely displaced. In the normal subjects the flush of the reactive hyperemia reached the toes within 60 seconds, usually within 15 seconds, after release of the circulation.

3. *The Reactive Hyperemia:* During the occlusion-reactive hyperemia test, the reactive hyperemia or flush was studied in the toes in some of the normal and trench foot subjects to learn if there were any differences between the two groups of subjects: (1) in the time of onset in the toes; (2) in the length of time required for it to reach a maximum and (3) in the degree of flush developed. Since Lewis' color charts (10) did not lend themselves to an estimation of the degree of the flush, an arbitrary set of standards was established. The greatest degree of flush was considered a *six plus flush* and no flush as *zero flush*, thus making it possible to delineate seven grades of intensity of flush. The time of onset and time required for a maximum flush to be reached were measured in seconds from the moment of release of the circulation following the period of occlusion. Since it was impractical to estimate

these phenomena for both feet, only the toes of the right foot were observed. All of these measurements were performed by one person, who became quite proficient and trained in the estimations, and who was unaware of the interpretation of his findings.

These results are summarized by Tables 5, 6, 7, and 8. It can be seen that in general there was no significant difference in the time required for the flush to appear or for the maximum degree of flush to be reached. There was, however, a greater intensity of flushing in the patients with Classes Ib and Ic trench foot than in the normal subjects or the Class Ia trench foot patients.

4. *Rate of Refilling of Skin Vessels:* During the course of the occlusion-reactive hyperemia test, the length of time required for the vessels of the skin to refill once they had been emptied by pressure was estimated. This was done on the medial aspect of both toes, where superficial gangrene often develops in trench foot. These measurements were made in some of the normal and trench foot subjects. Pressure was applied firmly by grasping the medial aspects of the big toes with the thumb and the lateral aspects with the index and middle fingers. The pressure was maintained for about two seconds and then suddenly released, the time required for the blanched area fully to regain its color was measured in seconds. An effort was made to succeed with the measurements on the first attempt since the vessels were most probably altered locally by the pressure and ischemic effects, rendering succeeding measurements valueless. Such a measurement was made two minutes after entrance of the subject in the air conditioned room, again after 15 minutes in the room, and then at the conclusion of the occlusion-reactive hyperemia test just before the subject got out of bed to dress.

The results of these observations are shown in detail in Tables 5, 6, 7, and 8. The initial rate of refilling of the blanched skin vessels was greater in the normal subjects and those with Class Ic trench foot than in those with Classes Ia or Ib trench foot. However, as the subjects rested in the room at 20°C. (68°F.), the rate of filling of the blanched vessels of the skin decreased only slightly in the subjects with Class Ic trench foot, but decreased markedly in the normal subjects and in Class Ia trench foot patients. Those patients with Class Ib trench foot showed a decrease in the filling rate which was intermediate be-

tween that of the normal subjects and the Class Ic trench foot patients. There were essentially no differences in the refilling time in the right and left toes. These results indicate a much more labile blood supply in the normal subject, that is, a blood supply more adaptable to environmental cooling. The results, furthermore, indicate the fact that under the influence of cooling a greater amount of vasospasm occurred in the normal than in the Class Ic trench foot subject. For example, in the normal subject after 15 minutes of cooling the mean refilling time for both feet increased from 4.6 seconds to 8.0 seconds, an increase of 74 per cent. By the end of the experiment, the mean refilling time for both feet had reached 11.2 seconds, or an increase of 143 percent over the initial refilling time. In the Class Ic trench foot patients the mean initial refilling time for both feet was 4.1 seconds, and at the end of 15 minutes' stay in the cool room it had reached 5.3 seconds, an increase of only 29 percent. By the end of the experiments the refilling time had reached a mean of only 6.4 seconds or an increase of 56 percent over the initial mean.

This failure of the circulation of the foot of the trench foot patient to respond to environmental cooling, at least so far as the skin is concerned, may be an important factor in the subsequent sensitivity of these patients to extremes of environmental cold. The failure of trench foot to show a normal vasospastic response under the influence of the cool room may be evidence of nerve damage secondarily involving arteriolar function, rendering the nervous system less effective in pacing the arteriolar caliber to environmental needs. This failure is also concerned with local chemical vasodilating factors associated with inflammation.

C. *Temperature of Various Parts of the Foot at Rest*

During the course of the occlusion-reactive hyperemia test, the temperature of various parts of the feet was noted at the end of the first 15 minutes' rest in bed in the observation room. Preliminary and orientation studies suggested that there might be a difference in the resting temperature of the feet under constant room conditions. The results are summarized by Table 9, and Figures 20 and 21. It can be seen that the patients with chronic trench foot tend to have warmer feet in direct ratio with the severity of their disease than the normal subjects

or the patients with psychoneurosis. This is true not only for the foot as a whole but for the various individual portions of the feet studied (Figures 20 and 21 and Table 9). For example, the mean temperature for the four areas of the right foot of the patients with trench foot was 27.49 ± 0.27°C., for the same four areas on the left foot 26.87 ± 0.24°C., and for both feet together 27.18 ± 0.18°C. In the normal subjects, the mean temperature for the four areas of the right foot was 25.67 ± 0.26°C., for the left foot 25.03 ± 0.08 C., and for both feet 25.35 ± 0.23°C. Thus the feet of the trench foot patients tended to be about 2°C. warmer than the feet of the normal subjects. The differences for each of the mean values for the normal subjects and the patients with trench foot were highly significant, with the probability of error varying from one in 31 to one in 6.5 million, depending upon whether or not a comparison is made between the warmest normal foot and the coldest trench foot temperature values (9). The mean values and statistical constants for the various areas of the feet are shown in the Table 9.

The mean temperature of the right big toe of the psychoneurotic patients was 25.2°C.; this is essentially 2.1°C. lower than that of the trench foot patients. The temperature of the various areas of all the feet studied tended to follow that for the right big toe as a whole.

From these observations it became obvious that temperature levels greater than 27°C. were more frequently encountered for various portions of the feet of patients with trench foot at the end of 15 minutes in bed in a room at 20°C. than in a comparable group of normal subjects or patients with psychoneurosis. In the control subjects (normal male and female and psychoneurotic) there were relatively few temperature values above 27°C. For example, when considering 136 temperature measurements for various portions of both feet of normal males only 22, or 16.2 per cent were greater than 27°C., and none of these was greater than 29°C. On the other hand, of 351 temperature measurements of both feet of the trench foot patients 161 values or 45.9 per cent were greater than 27°C. Essentially the same relationships hold for the various portions of the feet when considered separately (Figures 20 and 21).

The more severe the chronic trench foot, the higher the temperature observed for the feet. For example, it was found that the mean tem-

TABLE 9

Statistical Constants for the Temperature in Degrees Centigrade for Various Portions of the Feet of Patients with Mild Chronic Trench Foot and Control Subjects

The temperature values were obtained at the end of 15 minutes rest in bed in a room at 20°C. (68°F.). See the text for details.

	MEAN	RANGE	STANDARD DEVIATION	COEFFICIENT OF VALUATION
Normal male soldier				
Right foot	25.67 ± .26	22.0–30.4	3.3 ± .2	12.9 ± .7
Left foot	25.03 ± .08	21.2–31.0	3.7 ± .2	14.8 ± .9
Both feet	25.35 ± .23	21.2–31.0	4.1 ± .2	16.2 ± .7
Rt. bunion area	27.28 ± .32	25.1–29.5	2.0 ± 0.2	7.3 ± 0.8
Rt. big toe tip	25.08 ± .41	22.7–29	2.6 ± .3	10.4 ± 1.2
Rt. 2nd toe tip	24.44 ± .37	22 –30.4	2.3 ± .3	9.4 ± 1.1
Rt. corn area	25.78 ± .38	23 –30	2.4 ± .3	9.3 ± 1.1
Lt. bunion area	26.64 ± .45	23 –29.9	3.6 ± .4	13.4 ± 1.5
Lt. big toe tip	24.39 ± .5	21.7–31	3.2 ± .4	13.1 ± 1.5
Lt. 2nd toe tip	23.72 ± .40	21.2–29.9	2.5 ± .3	10.5 ± 1.2
Lt. corn area	25.17 ± .43	22.8–21.2	2.7 ±	10.7 ± 1.2
Trench foot 1a				
Right foot	26.65 ± .29	22.2–34.2	4.4 ± .2	16.5 ± .8
Left foot	26.44 ± .27	22 –33	4.1 ± .2	15.5 ± .7
Both feet	27.06 ± .19	22 –34.2	4.2 ± .1	15.5 ± .5
Rt. bunion area	27.83 ± .51	24.2–30.8	3.9 ± .4	14.0 ± 1.3
Rt. big toe tip	26.26 ± .50	22.2–34.2	3.8 ± .4	14.5 ± 1.4
Rt. 2nd toe tip	25.76 ± .50	22.8–34.1	3.8 ± .4	14.8 ± 1.4
Rt. corn area	27.06 ± .33	23.3–30.7	2.5 ± .2	9.2 ± .9
Lt. bunion area	27.47 ± .30	23.6–30.8	2.3 ± .2	8.4 ± .8
Lt. big toe tip	26.11 ± .49	22 –31.8	3.7 ± .3	14.2 ± 1.3
Lt. 2nd toe tip	25.46 ± .45	22.8–33	3.4 ± .3	13.4 ± 1.3
Lt. corn area	26.50 ± .4	25.2–29.7	3.1 ± .3	11.7 ± 1.1
Trench foot 1b				
Right foot	27.63 ± .49	23.9–34.1	4.1 ± .3	14.8 ± 1.3
Left foot	25.31 ± .33	22.6–28.2	2.8 ± .2	11.1 ± .9
Both feet	26.48 ± .33	22.6–34.1	3.9 ± .02	14.7 ± .1
Rt. bunion area	28.8	24.8–29	2.37	8.23 ± 2.06
Rt. big toe tip	28.1	23.9–33	3.56	12.67 ± 3.17
Rt. 2nd toe tip	27.0	24 –33.4	3.42	12.67 ± 3.17
Rt. corn area	26.7	26.8–34.1	1.59	5.96 ± 1.49

TABLE 9—*Continued*

Trench foot 1b—*Continued*

	MEAN	RANGE	STANDARD DEVIATION	COEFFICIENT OF VALUATION
Lt. bunion area	26.5	24 –28	1.19	4.49 ± 1.12
Lt. big toe tip	25.2	22.6–27.9	1.61	6.39 ± 1.60
Lt. 2nd toe tip	24.3	22.9–28.2	1.62	6.67 ± 1.67
Lt. corn area	25.4	25 –28.1	1.31	5.16 ± 1.29
Trench foot 1c				
Right foot	29.50 ± .57	24.8–33.5	5.1 ± .4	17.3 ± 1.4
Left foot	29.47 ± .58	24.8–35.4	5.1 ± .4	17.3 ± 1.4
Both feet	29.49 ± .04	24.8–35.4	5.2 ± .3	17.6 ± 1.0
Rt. bunion area	29.8	24.8–32.2	2.29	7.68 ± 1.81
Rt. big toe tip	29.9	24.9–31.4	3.19	10.67 ± 2.52
Rt. 2nd toe tip	28.0	26 –33.5	2.85	10.18 ± 2.40
Rt. corn area	30.0	26.3–32.9	2.23	7.43 ± 1.75
Lt. bunion area	29.8	25.2–33.9	1.86	6.24 ± 1.56
Lt. big toe tip	30.2	24.8–31.3	2.42	8.01 ± 1.89
Lt. 2nd toe tip	27.6	24.8–35.4	2.09	7.57 ± 1.78
Lt. corn area	30.0	26.6–32.2	3.03	10.10 ± 2.38
Entire group of trench foot				
Right foot	27.49 ± .27	22.2–34.2	5.2 ± .2	18.9 ± .7
Left foot	26.87 ± .24	22 –35.4	4.6 ± .2	17.1 ± .6
Both feet	27.18 ± .18	22 –35.4	4.9 ± .1	18.0 ± .5
Rt. bunion area	28.43 ± .49	24.2–32.2	4.8 ± .4	16.9 ± 1.26
Rt. big toe tip	27.43 ± .51	22.2–34.2	5.0 ± .4	18.2 ± 1.4
Rt. 2nd toe tip	26.50 ± .47	22.8–34.1	4.6 ± .3	17.4 ± 1.3
Rt. corn area	27.59 ± .34	23.3–34.1	3.3 ± .2	12.0 ± .9
Lt. bunion area	27.76 ± .25	23.6–33.9	2.4 ± .2	8.6 ± .6
Lt. big toe tip	26.75 ± .45	22 –31.8	4.4 ± .3	16.4 ± 1.2
Lt. 2nd toe tip	25.77 ± .36	22.8–35.4	3.5 ± .3	13.6 ± 1.0
Lt. corn area	27.05 ± .41	25 –32.2	4.0 ± .3	14.8 ± 1.1
Psychoneurotic				
Rt. big toe tip	25.3 ± .4	21.8–31.0	4.0 ± .3	15.8 ± 1.2
Rt. 2nd toe tip	24.8 ± .30	21.8–28.1	3.3 ± .21	13.3 ± 1.0
Both toes	25.33 ± .23	21.8–35.9	3.3 ± .2	13.1 ± .7

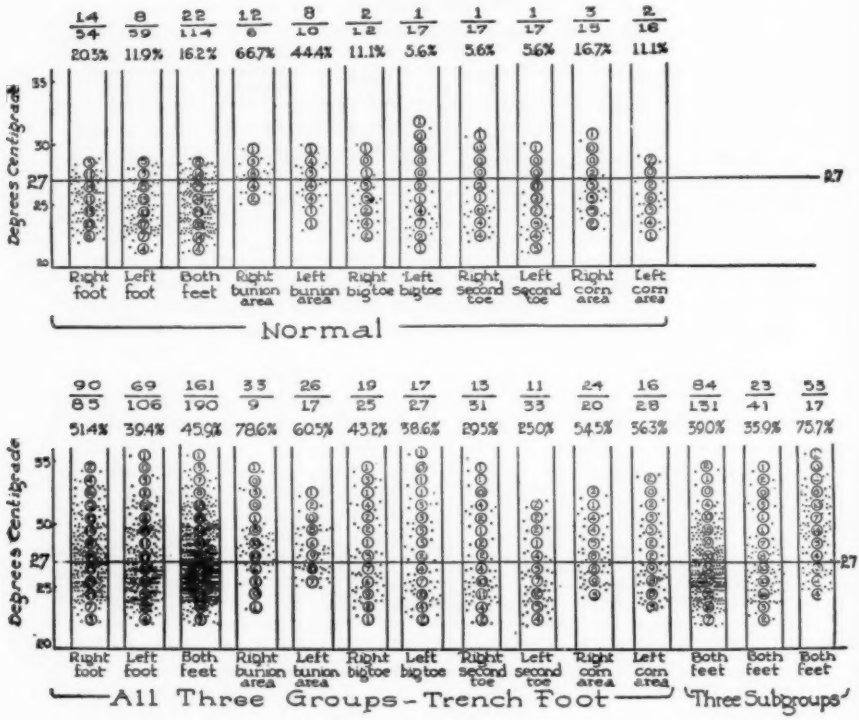

FIG. 20. A spot and summary graph of the temperature values of various areas of the feet of normal subjects and patients with trench foot after 15 minutes rest in bed in a room at 20°C. (68°F.). The temperature level of 27°C. (80.6°F.) was selected as a dividing line which tends to indicate a difference in the temperature of the parts in the two groups of subjects. The numerators of the fractions shown represent the number of temperature values above 27°C. and the denominator represents the number of values below 27°C. The percent values represent the per cent of the total temperature measurements which were above 27°C. In the lower graph, the three subgroups of trench foot represent from left to right, Classes Ia, Ib and Ic respectively.

perature of both feet was 26.5°C. in the patients with Class Ib chronic trench foot, while on the other hand the mean value was 29.4°C. for the

patients with Class Ic chronic trench foot. In the Class Ia chronic trench foot, of 215 temperature measurements of the feet, 84 or 39 per cent were greater than 27°C., while in the Class Ic chronic trench foot, 53 of 70 temperature measurements or 75.7 per cent were greater than 27°C.

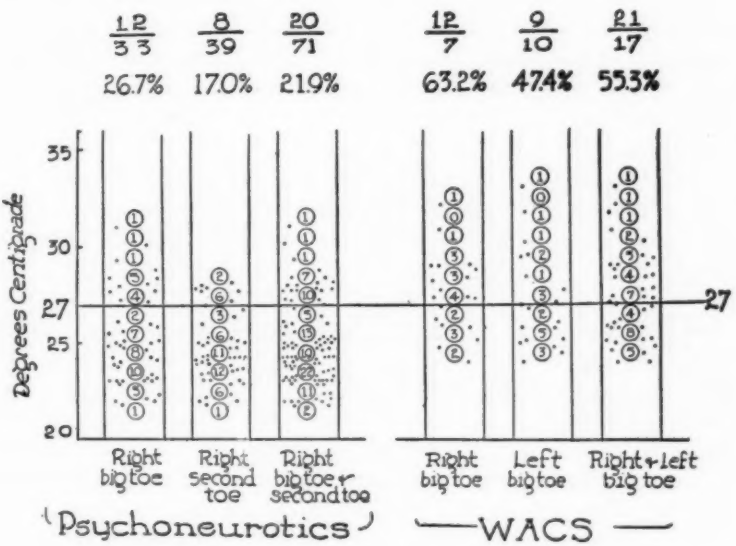

FIG. 21. A spot and summary graph of the temperature values of various parts of the feet of psychoneurotic patients and normal female subjects of the Women's Army Corps after 15 minutes rest in bed at a room temperature of 20°C. (68°F.). Twenty-seven degrees centigrade was selected as a dividing line with the fractions and percentage values as indicated in Figure 20.

It is understood that where gangrene is present, as is found in Class III trench foot, these observations may not necessarily apply. The values would depend upon the degree of gangrene and the site of application of the thermocouples. The temperature of the involved part would not reflect the temperature of the foot as a whole, since the very existence of gangrene demonstrates occlusion of the circulation.

D. *Rate of Water Loss Through the Skin and Sweating*

The rates of water loss through the skin of subjects with mild chronic trench foot (Classes Ia, Ib, Ic) and normal controls were studied simultaneously in a comfortable environment (temp. 20.3°C. (68.5°F.), 74 per cent mean relative humidity). Following these measurements under comfortable environmental conditions the room atmosphere was made hot and humid (mean temp. 48.7°C. (119.8°F.); mean relative humidity 53 per cent). Details of the environmental conditions are indicated in Tables 10 and 11. Since it was unnecessary, room conditions were not controlled too closely from experiment to experiment. The rates of water loss by sensible sweating were measured.

Methods used in these studies are those described elsewhere (11, 12). The measurements are direct and gravimetric. A normal and a trench foot subject rested in separate adjacent beds during these measurements, thus controlling in each experiment any variations in the environmental and other conditions. By such simultaneous measurements, although the conditions of the environments might vary somewhat from experiment to experiment, and by the mere fact that a normal and a trench foot subject were studied simultaneously under the same environmental conditions, any differences for the two groups of subjects (normals and trench foot) will be significant and adequately controlled. A five square centimeter area on the sole and dorsum of the right foot of 25 normal male subjects and 25 patients with trench foot was observed. The collections of sweat were made for 15 minute periods, three successive 15 minute collections being made for each environmental condition. The rates of water loss were expressed in milligrams per 10 square centimeters of skin area per 10 minutes.

The results are summarized in Tables 10 and 11 and Figure 22. The mean rate of water loss in the comfortable environment for the dorsum of the foot of the normal subjects was 5.6 mg. per 10 cm^2 skin area per 10 minutes (extremes 2.0 and 8.8) and the mean for the sole of the foot was 12.6 mg. per 10 cm^2 per 10 minutes (extremes 4.4 and 22.8). In the hot and humid environment the mean rate for the dorsum of the foot was 81.0 (extremes 33.6 and 151.2) and 33.8 (extremes 17.7 and 70.0) for the sole.

In the *patients with trench foot* the mean rate of water loss in the comfortable environment was 5.6 mg. per 10 cm^2 per 10 minutes (extremes

TABLE 10

The Rates of Water Loss in Comfortable and a Hot and Humid Environment from the Skin of the Dorsum and Sole of the Right Foot of 25 Normal Young Resting Adult Subjects

Subject	COMFORTABLE ENVIRONMENT				HOT AND HUMID ENVIRONMENT			
	Rate of water loss mg./10 cm²/10 min.	Room temperature °F.	Room temperature °C.	Relative humidity %	Rate of water loss mg./10 cm.²/10 min.	Room temperature °F.	Room temperature °C.	Relative humidity %
Dorsum of foot								
W.H.	6.2	69	20.5	76	126.4	118	47.7	76
D.D.	6.4	68	20.0	80	54.0	124	51.1	48
F.N.	4.0	68	20.0	67	73.6	120	48.8	53
S.H.	6.6	68	20.0	76	48.0	118	47.7	51
T.C.D.	6.0	69	20.5	85	74.4	120	48.8	55
S.H.W.	3.6	68.5	20.3	83	63.2	124	51.1	52
L.S.	8.6	68	20.0	71	110.8	124	51.1	52
H.G.	8.0	68	20.0	80	77.6	119	48.3	55
G.W.	2.4	67.5	19.7	73.5	90.8	120	48.8	55
E.S.C.	8.8	68	20.0	80	135.2	115	46.1	80
C.R.	4.8	70	21.1	72	74.0	126	52.2	44
A.S.	3.4	68	20.0	64	151.2	118	47.7	64
P.D.	3.4	68.5	20.3	71.5	104.8	124	51.1	103
S.H.	2.0	68	20.0	71	73.2	122	50.0	46
L.B.	4.0	69.5	20.8	70	118.0	120	48.8	47
H.M.	8.0	67.5	19.7	78	64.0	116	46.6	57
V.G.	5.8	69	20.5	63	112.0	120	48.8	51
P.B.R., Dr.	6.8	69	20.5	72	77.2	122	50.0	52
L.S.	6.0	67.5	19.7	73	33.6	105	40.5	69
H.P.	7.8	69	20.5	76	84.4	120	48.8	53
W.K.	5.8	68.5	20.3	69.5	51.2	122	50.0	51
S.S.	6.0	67.5	19.7	69	34.0	120	48.8	49
F.N.	5.8	68	20.0	74	53.6	118	47.7	47
J.B.F., Dr.	6.0	68	20.0	76	96.4	122	50.0	52
J.C.	4.2	69	20.5	72	50.4	115	46.1	49.5
Mean.....	5.6	68.4	20.2	73.7	81.2	119.6	48.7	52.8
Max.....	8.8	70	21.1	85	151.2	126	52.1	100
Min.....	2.0	67.5	19.7	63	33.6	105	40.5	44
Sole of foot								
W.H.	12.2	69	20.5	76	29.6	118	47.7	76
D.D.	10.6	68	20.0	80	22.4	124	51.1	48
F.N.	5.2	68	20.0	67	25.2	120	48.8	53
S.H.	9.4	68	20.0	76	23.2	118	47.7	51

TABLE 10—*Continued*

Subject	COMFORTABLE ENVIRONMENT				HOT AND HUMID ENVIRONMENT			
	Rate of water loss mg./10 cm.²/10 min.	Room temperature °F.	Room temperature °C.	Relative humidity %	Rate of water loss mg./10 cm.²/10 min.	Room temperature °F.	Room temperature °C.	Relative humidity %
Sole of foot—*Continued*								
T.C.D.	7.6	69	20.5	85	29.6	120	48.8	55
S.H.W.	17.0	68.5	20.3	83	28.0	124	51.1	52
L.S.	10.8	68	20.0	71	25.6	124	51.1	52
H.G.	13.2	68	20.0	80	28.0	119	48.3	58
G.W.	8.2	67.5	19.7	73.6	26.8	120	48.8	55
E.S.C.	16.2	68	20.0	80	56.4	115	46.1	80
C.R.	7.4	70	21.1	72	26.4	126	52.2	44
A.S.	6.2	68	20.0	64	42.0	118	47.7	64
P.D.	7.8	68.5	20.3	71.5	70.0	124	51.1	103
S.H.	4.4	68	20.0	71	24.8	122	50.0	46
L.B.	7.6	69.5	20.8	70	26.8	120	48.8	47
N.H.	22.8	67.5	19.7	78	47.6	116	46.6	57
V.G.	13.2	69	20.5	63	65.2	120	48.8	51
P.B.R., Dr.	10.2	69	20.5	72	36.8	122	50.0	52
L.S.	10.6	67.5	19.7	73	41.2	105	40.5	69
H.P.	7.0	69	20.5	76	17.6	120	48.8	51
W.K.	9.0	68.5	20.3	69.5	50.8	122	50.0	53
S.S.	9.4	67.5	19.7	69	22.0	120	48.8	49
F.N.	7.2	68	20.0	74	27.6	118	47.7	47
J.B.F., Dr.	10.4	68	20.0	76	24.8	122	50.0	52
J.C.	7.8	69	20.5	72	26.4	115	46.1	49.5
Mean.....	12.6	68.4	20.2	73.7	33.8	119.6	48.7	52.9
Max.....	22.8	70	21.1	85	70.0	126	52.1	100
Min.....	4.	67.5	19.7	63	17.7	1.05	40.5	44

2.0 and 19.0) for the dorsum of the foot and 10.8 (extremes 3.4 and 21.2 for the sole. In the hot and humid environment, the mean rate for the dorsum of the foot was 86.1 (extremes 25.2 and 150.4) and 34.9 (extremes 20.0 and 74.4) for the sole. It was found, therefore, that the rates of sensible perspiration (mainly water of diffusion through the skin) (13) and sensible perspiration were essentially the same in the normal and chronic trench foot subjects (Figure 22).

In the comfortable environment the water loss was mainly by diffusion (13), and in the hot and humid environment the loss was mainly

TABLE 11

The Rates of Water Loss in a Comfortable and a Hot and Humid Environment from the Skin of the Dorsum and Sole of the Right Foot of 25 Resting Trench Foot Subjects of all Classes

Subject	COMFORTABLE ENVIRONMENT				HOT AND HUMID ENVIRONMENT			
	Rate of water loss mg./10 cm.²/10 min.	Room temperature °F.	Room temperature °C.	Relative humidity %	Rate of water loss mg./10 cm.²/10 min.	Room temperature °F.	Room temperature °C.	Relative humidity %
Dorsum of foot								
F.W.	4.6	69	20.5	76	113.6	118	47.7	76
J.A.	7.2	68	20.0	80	70.8	124	51.1	48
W.W.	2.0	68	20.0	67	56.0	120	48.8	53
H.J.	7.0	68	20.0	76	100.0	118	47.7	51
W.H.	4.0	69	20.5	85	90.8	120	48.8	55
C.S.	19.0	68.5	20.3	83	98.0	124	51.1	52
J.C.	5.8	68	20.0	71	118.4	124	51.1	52
C.H.	7.8	68	20.0	80	81.2	119	48.3	55
J.D.	6.0	67.5	19.7	73.5	124.0	120	48.8	55
E.M.	8.8	68	20.0	80	150.4	115	46.1	80
S.H.	2.9	70	21.1	72	73.6	126	52.2	44
S.J.C.	2.4	68	20.0	64	91.2	118	47.7	64
C.G.	4.2	68.5	20.3	71.5	145.2	124	51.1	103
H.D.	3.2	68	20.0	71	70.0	122	50.0	46
E.C.	3.0	69.5	20.8	70	128.4	120	48.8	47
C.C.	10.4	67.5	19.7	78	80.8	116	46.6	57
W.F.	9.6	69	20.5	63	120.0	120	48.8	51
L.N.	3.2	69	20.5	72	71.6	122	50.0	52
H.J.	4.6	67.5	19.7	73	52.8	105	40.5	69
B.K.	6.0	69	20.5	76	67.6	120	48.8	53
J.D.	5.6	68.5	20.3	69.5	60.0	122	50.0	51
R.T.	2.6	67.5	19.7	69	51.2	120	48.8	49
L.L.	4.0	68	20.0	74	25.2	118	47.7	47
E.Mc.	4.8	68	20.0	76	76.0	122	50.0	52
G.A.	4.0	69	20.5	72	35.2	115	46.1	49.5
Mean.....	5.6	68.4	20.2	73.7	86.1	119.6	48.7	52.8
Max.....	19.0	70.0	21.1	85	150.4	126	52.2	103
Min.....	2.0	67.5	19.7	63	25.2	105	40.5	44
Sole of foot								
F.W.	19.8	69	20.5	76	35.2	118	47.7	76
J.A.	10.6	68	20.0	80	24.0	124	51.1	48
W.W.	5.0	68	20.0	67	24.0	120	48.8	53

TABLE 11—*Continued*

Subject	COMFORTABLE ENVIRONMENT				HOT AND HUMID ENVIRONMENT			
	Rate of water loss mg./10 cm.²/10 min.	Room temperature		Relative humidity %	Rate of water loss mg./10 cm.²/10 min.	Room temperature		Relative humidity %
		°F.	°C.			°F.	°C.	
	Sole of foot—*Continued*							
H.J.	12.0	68	20.0	76	24.4	118	47.7	51
W.H.	16.2	69	20.5	85	22.0	120	48.8	55
C.S.	21.2	68.5	20.3	83	24.8	124	51.1	52
J.C.	16.2	68	20.0	71	24.4	124	51.1	52
C.H.	11.2	68	20.0	80	32.4	119	48.3	58
J.D.	8.0	67.5	19.7	73.5	23.2	120	48.8	55
E.M.	10.0	68	20.0	80	98.8	115	46.1	80
H.S.	9.8	70	21.1	72	48.0	126	52.2	44
S.J.C.	8.2	68	20.0	64	48.4	118	47.7	64
C.G.	3.6	68.5	20.3	71.5	28.4	124	51.1	103
H.D.	3.4	68	20.0	71	28.8	122	50.0	46
E.C.	7.2	69.5	20.8	70	43.6	120	48.8	47
C.C.	14.0	67.5	19.7	78	30.4	116	46.6	57
W.F.	16.2	69	20.5	63	74.4	120	48.8	51
L.N.	8.8	69	20.5	72	39.6	122	50.0	52
H.J.	10.6	67.5	19.7	73	34.0	105	40.5	69
B.K.	6.0	69	20.5	76	26.0	120	48.8	53
J.D.	19.0	68.5	20.3	69.5	32.0	122	50.0	51
R.T.	7.8	67.5	19.7	69	20.4	120	48.8	49
L.L.	9.0	68	20.0	74	20.0	118	47.7	47
E.Mc.	8.0	68	20.0	76	40.0	122	50.0	52
G.A.	7.4	69	20.5	72	26.0	115	46.1	49.5
Mean.....	10.8	68.4	20.2	73.7	34.9	119.6	48.7	52.9
Max.....	21.2	70.0	21.1	85	74.4	126	52.1	103
Min.....	3.4	67.5	19.7	63	20.0	105	40.5	44

by sensible perspiration or the secretion of sweat by the sweat glands. Figure 22 shows that under the influence of a strong stimulus (of a hot and humid environment) to sweating, sweating from the soles is stimulated relatively little the rate of the water loss being only about three times greater than that in a comfortable environment. On the other hand, the rate of water loss from the dorsum of the foot increased about 14.5 times over that for the same area of skin in a comfortable environment. In the comfortable environment, however, the rate of

water loss was about twice as rapid from the skin of the sole as that from the skin of the dorsum of the foot.

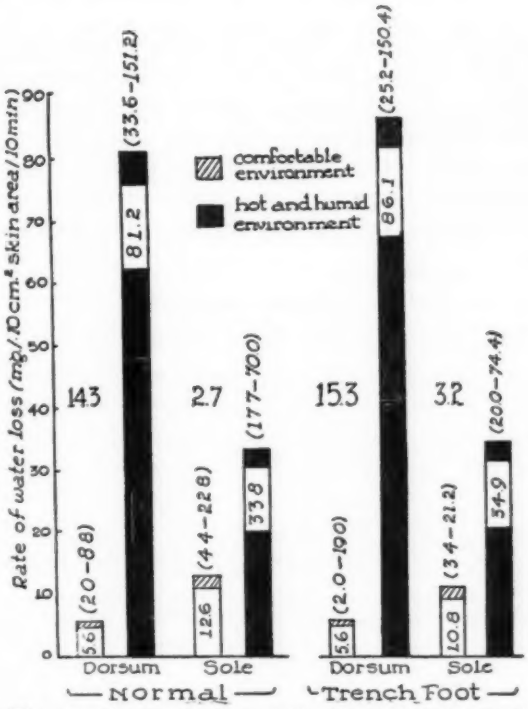

FIG. 22. The rates of water loss through the skin of Class I trench foot patients and normal control subjects compared for a comfortable environment (mean temperature 20.3°C. (68.5°F.), mean humidity 74%) and a hot, humid environment (mean temperature 48.7°C. (119.8°F.), mean humidity 53%). An area of 5 square centimeters was selected for study on the sole and dorsum of the feet.

The values 14.3, 2.7, 15.3 and 3.2 represent the number of times the rates of water loss increased in the hot and humid environment over that in the comfortable environment.

Since the number of sweat glands in the sole of the foot is essentially 2.5 times the number per unit area on the dorsum and the rate of sweat water loss on the dorsum of the foot is essentially 2.5 times that on the

sole in the hot and humid environment, the individual sweat gland on the dorsum of the foot produced sweat at a rate over six times that of an individual gland of the sole when the environment was hot and humid.

The finding of equal rates of sweating for the normal and trench foot subjects both in the comfortable and hot and humid environments certainly indicates a normal functional state of the sweat glands in these mild chronic trench foot patients. This was true for all three grades of mild chronic trench foot, indicating that the functional repair of at least the superficial dermal structures had occurred even in Class Ic. Popoff (7) has found that the anatomic restoration of sweat glands occurs relatively early.

IV. GENERAL DISCUSSION

All considerations relevant to the above data must be influenced by the prime consideration that this discussion is limited to mild chronic trench foot. A period of at least five to nine months has elapsed between the most recent exposure to the etiologic factors concerned with trench foot and these studies. Severe cases were not studied. Although many of the findings may very well apply in either more acute or more severe forms of the disease than are dealt with in this paper, since they have not been tested here, it is unsound to base any predictions on them.

The fact that these studies were conducted in summer in New Orleans, where the weather is warm and humid, may have influenced these data. Naide (8, 9) had devised a test for vascular tone in man with criteria which do not apparently hold true in these studies. Perhaps the fact that his work was done in Philadelphia while this work was done in New Orleans may be the source of differences. Subjects acclimatized to warm humid weather may manifest differences in circulation from those subjected to a colder, drier climate in spite of the fact that both groups may be under identical conditions of temperature and humidity in the control room during the actual observations.

A group of subjects were tested on a basal fasting routine and also from two to three hours after meals. No difference was demonstrated in these groups, as far as skin temperature is concerned; hence there is no need to interrupt the regular meal schedule. The only essential

factor is that at least two hours must elapse between the most recent meal and the test.

An important consideration is the accurate (±0.25°C.) control of temperature in the constant temperature room. The skin thermocouples are influenced by environmental temperature *per se* as well as the temperature of the subjects' skin. Variations in environmental temperature will therefore influence the temperature readings and provide an important source of error. Since one is interested in variations in skin temperature only, the room temperature must be kept constant. Humidity control need not be as accurate as temperature control. A range of from 50 to 65 per cent is permissible. Humidity above or below these critical levels will produce either delayed or accelerated surface evaporation, and thus interfere with temperature control. This humidity range is not difficult to attain and quite comfortable for the patient.

The duration of the subject's stay in the control room must be accurately measured and controlled. Evaluation of skin color, disappearance and return of skin color on pressure, and so on, (Tables 5, 6, 7, and 8) are greatly influenced by the duration of time the subject has spent in the control room. Since duration of exposure and environmental temperature have considerable influence upon the caliber of skin vessels, careful regulation of temperature and duration of exposure are essential to proper evaluation of vascular and thermal phenomena.

Judging skin color is a rather inaccurate procedure. For that reason, all skin color studies are considered as "quasi-objective." There are considerable individual variations among the observers. Skin color is frequently patchy rather than uniform, thus rendering it difficult to decide which areas of skin represent the significant color changes.

The disappearance and return of skin color on pressure may also be classes as a "quasi-objective" test. Accurate timing of the phenomenon is difficult. Nevertheless, observations in the resting extremity two minutes after entering the control room, 15 minutes later and then at the end of the experiment disclosed interesting facts (Tables 5, 6, 7, 8). The Class Ic trench foot patients have demonstrated the existence of dilated skin vessels with a failure to adapt to environmental

cooling by manifesting a consistently more rapid "refilling time" throughout the study. The Class Ib patients showed a "refilling time" intermediate between normal and Class Ic. Apparently the local circulatory responses of the subpapillary venous plexus, capillary bed as well as the arterioles, are inhibited in their reaction to environmental cooling in Class Ic trench foot. In moderate atmospheric conditions, such as prevail in the control room, this is a subclinical phenomenon uncovered only by careful testing. Under more extreme atmospheric conditions the failure of the superficial vessels to keep pace with environmental needs may be at least a factor in the abnormal sensitivity which trench foot patients manifest to extremes of heat or cold. At earlier or more acute stages of the disease the rates of refilling of pressure emptied skin vessels are probably quite different from those in the mild chronic trench foot.

The studies of sweating have disclosed a complete regeneration of the sweat gland function in this group of mild chronic trench foot. These measurements have been of no value in differentiating normal from trench foot subjects or quantitating the degree of trench foot in this group. Nevertheless, since there is an early return of this type of skin appendage to normal after superficial tissue destruction, the measurement of sweat may be used as an early sign of functional regeneration of superficial tissue. The so-called "perspiratory personality" (14) and the numerous clinical references to the presence of excessive sweating as a manifestation of vasomotor instability in trench foot have not been supported in these studies of mild chronic trench foot The interesting physiologic difference of the functional qualities of the sweat glands of the sole and of the dorsum of the foot discovered in these studies has been indicated above.

In the introductory remarks the premise that chronic mild trench foot patients are probably suffering from a form of inflammation, which is produced by physical agents, was discussed. Descriptions of chronic inflammation already available in the literature in support of this concept have already been mentioned. The results of the observations described above serve to confirm this premise. For example, the initial temperature (Table 3, Figures 1 through 9) of the foot in the trench foot patient was higher in general than a homologous part in the normal subject. The more severe the clinical picture, the higher

was the initial pedal temperature. Such findings are compatible with the presence of inflammatory reaction manifested by superficial vasodilatation. In addition, it was noted in the occlusion-reactive hyperemia test that the degree of reactive hyperemia, as evidenced by the degree of rise in temperatures from the reactive hyperemia effect, was more pronounced in trench foot than in the normal subject. The degree of change was directly proportional to the clinical severity of the case, that is, Class Ic showed greater change than Class Ib and Class Ib greater than Class Ia. There were only slight differences noted among Class Ia trench foot, normal and psychoneurotic subjects. Lewis (6) has shown that the degree of reactive hyperemia developed in a part following occlusion is directly related to the rate of metabolism and oxygen consumption. Inflammation accelerated the rate of tissue metabolism and oxygen consumption; therefore, all things being equal, during the period of occlusion a greater oxygen debt and hyperemia would be expected in the presence of inflammation as compared with normal tissue.

The relatively rapid refilling time of the blood vessels of the skin in the trench foot patient supports the existence of vasodilatation which could be inflammatory. The fact, however, that the period of stay in an atmosphere of 20°C. (68°F.) failed to bring about a normal degree of vasoconstriction of the skin vessels is further support of the existence of inflammatory vasodilatation.

The clinical observations in these patients, as well as observations by others made on clinical and histologic studies, support the premise of chronic inflammation (2). Since demonstrable chronic inflammation may exist in mild chronic trench foot, a test demonstrating the presence or absence of continued activity of chronic trench foot should entail, in part, at least, the accumulation of data in support of the existence or non-existence of inflammation. Since very mild chronic trench foot subjects with activity and former trench foot patients who have returned to normal are being studied, the evidence of inflammation will *a priori*, be slight and subtle. Therefore, a test outlined below is designed to uncover or rule out, in part, at least, low grade inflammation.

Obviously, exact criteria cannot be set up on the basis of only 46 trench foot subjects. Due to unavoidable circumstances, the number

was limited. Adequate control studies were done, so that a foundation has been established to delineate the range of normal variations. Eighty-nine normal male, 51 psychoneurotic male, and 19 normal female subjects were studied, many of the subjects, normal and trench foot, being subjected to repeated observations. Thirteen miscellaneous patients with mild peripheral vascular disease were also examined. A total of 218 individual subjects were studied.

The evaluation of other forms of peripheral vascular disease for comparison purposes by these tests did not fall within the scope of this paper. Nevertheless, the control subjects in future studies should include many varieities of disease states. Such groups tend to orientate the test in relation to the normal and the abnormal. Abnormal controls would establish the specificity, if any, of this procedure in the field of peripheral vascular disease. It is known that the occlusive vascular diseases produce an extremity of reduced rather than elevated temperature. Where major peripheral vessels are occluded, local inflammation cannot initiate hyperemia easily because the functioning vascular channels are not adequate to supply the part with blood. The finding of increased temperature in an extremity and the demonstration of potentialities for a marked increase in that temperature would confirm the presence of relatively adequate vascular channels to the skin. The uniformly great increase in temperature after posterior tibial nerve block indicates in the cases of mild chronic trench foot at least that there is no great lack of potential vascular channels in this condition. The presence of adequate vascular channels does not, however, insure an efficient blood supply since these channels must be so controlled and integrated that they can pace themselves to the needs of the part. A test to determine the adequacy of circulation to a part must, therefore, establish not only the presence of adequate vascular channels but also the ability of these channels to react appropriately to the demands of the tissues of the part tested.

The results of the observations described above indicate very strongly that with certain simple, objective, correlated procedures it might be possible to show that a mild chronic trench foot has not returned to normal even though ordinary clinical studies show no abnormalities. Like the electrocardiogram in heart disease, the finding of normal reactions to the test outlined below cannot be considered defi-

nitely to rule out subtle or latent trench foot. It may, with further study, be safe to conclude otherwise. Furthermore, it is well to note at this time that the tests outlined in detail below show definite promise, but it would certainly be unsafe to generalize about their application at present, for many variables may modify chronic trench foot. Furthermore, the series, though observed repeatedly, was relatively small, a fact supported in part by statistical analyses (Table 3). It is also quite possible that the clinical evaluation in some of these patients may be in error. Criteria set upon the basis of clinical classification may be inaccurate. The subdivision of the mild chronic trench foot patients into classes Ia, Ib and Ic may certainly raise the question as to whether such a comparatively detailed subdivision can be made. Certain subjects considered as Class Ib might certainly be in Class Ia or vice versa, or patients listed in Class Ic might be in Ib or vice versa. There is little likelihood, however, that a Class Ic patient would be mistaken for a Ia patient or vice versa. The simplicity of the procedures and the definite nature of the findings, however, make it highly worthwhile to extend the observations to include many more patients with trench foot and control subjects, both normals and patients with many disease states. Such variables as climate, duration of the disease, occupation, age, exercise, shoes, type of clothing, and other factors should be checked. The tests outlined below are not complicated and can be applied to many subjects by technicians of usual training. Nevertheless, it is necessary to consider all details outlined seriously, for thermocouple determinations require special care in their use, even though they are simple to employ.

A. *Tests for Mild Chronic Active Trench Foot*

1. *Room conditions* must be uniformly controlled throughout to ensure a temperature of 20°C. (68°F.), with variations not to exceed ± 0.25°C. (±0.9°F.). The relative humidity may vary from 50 to 65 per cent. The rate of movement of the air in the room near the subject should not exceed 15 feet per second and should be uniform.

2. *Preparation of subject:* The subject requires no special preparations. He should not eat or smoke within three hours of the observations, and, of course, should be free from any complicating illnesses. He should rest comfortably in bed, nude, covered over the trunk from

the upper third of the thighs to the shoulders with an ordinary cotton sheet. A blood pressure cuff of six inch width (15 cm.) with about a six foot length cloth is wrapped snugly, but not tightly, around the lower third of the thighs just above the knee. These cuffs, guarded by valves, are connected to a constant pressure tank of air automatically regulated to 280 mm. of mercury pressure. A thermocouple is placed on the pad of the tip of each big toe, if possible (more parts may be observed but this is not necessary. The application of the cuffs and thermocouples should not require over 90 seconds. The temperature of these two parts is measured continuously, preferably by an automatic pen recording galvanometer, until the test has been completed.

3. *Fifteen minute temperature of the parts:* The temperature of the part is noted at the end of the first 15 minute period of stay in the room.

4. *Rate of refilling of pressure emptied vessels of the skin:* The toe is squeezed firmly for about 12 seconds between the thumb and index and middle fingers by placing the thumb on the medial side of the subject's big toe and the two fingers on the lateral aspect. The pressure is suddenly released, and the time required for the emptied skin vessels to refill is measured by a stopwatch. "Refilling time" is measured at the end of two minutes' stay in the room, at the end of 15 minutes' stay, and again at the end of the entire study just before the subject gets out of bed to dress.

5. *Occlusion-reactive hyperemia test:* After the temperature of the parts has reached a stabilized baseline, that is, maximum difference in two successive temperature measurements of 0.2°C., the pressure in the blood pressure cuffs around the thighs is suddenly raised to 280 mm. mercury by opening valves connecting the lumina of the cuffs to the pressure tanks. At the end of 15 minutes of occlusion of the arterial and venous circulations the pressure in the cuffs is suddenly released by opening and closing proper valves. The temperature of the parts is measured continuously during the entire period.

B. *Interpretations*

Under the conditions in which these studies were conducted the following interpretations seem justified but require further evaluation and study:

(1). If the temperature of the part at the end of 15 minutes' stay in the room is above 29°C. there is almost 100 per cent chance that the

toe of the subject is not normal. If it is above 27°C. there is about a 75 per cent chance that the toe is not normal.

(2). At the end of two minutes and 15 minutes' stay in the observation room the rate of refilling of the pressure emptied skin vessels showed no significant difference between the trench foot and control subjects. If at the end of the entire study the rate of refilling is less than 8.0 seconds, the chances are almost 100 per cent that the part is not normal.

(3). In the occlusion-reactive hyperemia test, if the temperature of the big toe falls more than 5°C. during the period of occlusion and shows a maximum rise of 5 or more degrees centigrade during the period of reactive hyperemia, the chances are about 100 per cent that the part is still diseased. If the fall during the period of circulatory arrest is 3.6°C. and the rise during the period of reactive hyperemia is 4.4°C., the chances are about 90 per cent that the part is not normal. If the fall is greater than 3°C. and the rise after release of the circulation is greater than 3°C., the chances are about 75 per cent that the foot is abnormal. In fact, with a fall of 2°C. during the occlusion and a rise of 2°C. during release the patient has over a 50 per cent chance of being abnormal.

(4). When all three above phenomena are definitely abnormal in reaction, the chances of the part being diseased approach 100 per cent and are more definite than if one of these reactions were suggestively abnormal. The availability of two separate objective phenomena and one quasi objective phenomenon leads to greater accuracy. The accuracy is further ensured by observing a part on both sides simultaneously, one part being a control over the other.

V. SUMMARY AND CONCLUSIONS

The purpose of this study has been to find an objective test which will aid the clinician in determining whether or not patients who formerly had acute trench foot are still showing evidences of active disease. In trench foot patients with extensive tissue damage and tissue loss, pathology is apparent. Patients with subjective complaints lacking obvious objective disease present a difficult problem to evaluate precisely.

The premises (1) that trench foot is an inflammatory disease produced by exposure to cold and moisture and (2) that tissue reaction

and repair persist long after initial exposure have been important bases in this study. It was decided to investigate the value of temperature changes in the involved part as a major criterion for the existence and degree of inflammation. Temperature studies by means of skin thermocouples, supplemented by quasi objective evaluations of skin color and the rate of refilling of pressure emptied skin vessels, were used to uncover and quantitate local inflammation and the functional rate of the basal circulation. The comparative rates of water loss from the skin of normal and trench foot subjects were also observed. There was no remarkable difference in sweating between normal and trench foot subjects, whether in a comfortable or a hot and humid environment.

During the course of this study certain facts have become apparent. The initial temperatures of the foot of the mild chronic trench foot subject was higher than that of the normal or psychoneurotic subject, and there was a direct correlation between the clinical severity of the disease and the height of this temperature. Class Ia patients, who border on normalcy, showed very little difference, if any, from normals. Classes Ic and Ib patients showed a distinct difference from normal. Trench foot cases also showed a fall in temperature after the circulation to the foot was occluded and a reactive hyperemia rise after release of the circulation which were much greater than the normal but proportionate to the severity of the disease; Class Ic manifests the most extreme effects; Class Ia resembled normal most closely, and Class Ib fell about intermediately between Ia and Ic. Since the findings showed only minimal differences between the Class Ia trench foot and the normal, there may be overlapping. The methods used were quantitative while the clinical evaluations of the trench foot could not have been equally precise.

Trench foot subjects did not adapt to environmental cooling like the normal or psychoneurotic controls. This fact was demonstrated by studies conducted on the refilling time of pressure emptied skin vessels. The Class Ia subjects showed little difference from the normals. Class Ib showed a distinct difference, and the Class Ic patients manifested little tendency to adjust to environmental cooling at 20°C. (68°F.)

An index, which might be appropriately called the "Activity Index," based upon the features of initial stabilization temperature, number of

degrees temperature fall following 15 minutes of occlusion, and rise during hyperemia after release of the circulation can be devised to express the amount of inflammatory activity in a part injured by cold and moisture. Such an index might be further supported by data on the refilling time of pressure emptied skin vessels. It is not feasible at this time to base such a critical evaluation upon a comparatively small number of cases. An index which could numerically express activity and for which definite quantitative values can be stated to correspond with the degree of activity would simplify the handling of large numbers of subjects. The improvisation of such an index is quite possible. Certainly, further study over a larger group of trench foot subjects is warranted to find it. However, a group of observations have been outlined which seem to have promise as tests for activity in mild chronic trench foot. Based upon these limited studies, possible interpretations have also been indicated.

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THE USE OF THE PSYCHOSOMATIC CONCEPT IN MEDICINE

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The topic you have chosen to be discussed by me as the second lecture in the memory of Miss Brogden is very near to my heart, since, for the past twenty-eight years, much of my research I devoted to this subject. For this reason, I consider it not presumptuous to accept the honor of delivering the address to you today.

A discussion of the psychosomatic concept presupposes a clarification of what this concept means, how it developed, and how it moved so much into the center of our interests. Firstly, it must be stated that the concept is an old one, was renewed thirty years ago, and is today under scrutiny again. The old idea of the demons which enter the body and make it sick has been certainly abandoned, but not yet as completely as we would like to be the case; it has changed for some time to the idea of the magic power—rooted so deeply in the infantile idea of omnipotence—the magic power which remains to a great extent the nucleus of psychotherapy based on the concept of the exertion of mutual influence, between human beings. The demonic idea became replaced by the concept of hypnosis, suggestion and autosuggestion. For a long time this concept dominated the mind and body problem as far as research and therapy was concerned. Time and again, hypnotic experiments were conducted, repeated and duplicated up until today,to prove how emotional factors can influence physiological processes. Much coal was carried to Newcastle.

It would have led us into a blind alley if Freud's concept of the unconscious had not given the research a new impulse. He himself began his investigation with hypnotic therapy, until he discovered that not the conscious conflicts make somebody sick, but the forgotten, repressed, unresolved, unconscious conflicts lead to bodily changes, under given conditions. The first analytical research in this field is connected with the names of Ferenczi, Groddeck and Jellife. Having been Freud's physician at the time of the onset of and during his tragic disease, he influenced me to begin this research from the psychophysiological point of view. Then some twenty-five years ago, I (1)

used the term "psychosomatic" with the idea that this research aims, as I wrote at the time, to study the personality structure through the observation of the bodily behavior. I proposed as the goal of the therapy, to loosen the psychosomatic fusions, to clean, so to speak, the organ systems from the old psychic entanglement, and to free them from the unconscious, pathological, instinctual influences, in order to safeguard the biological functions.

As Freud's ideas paved the way for psychosomatic research from the psychoanalytical point of view, Cannon's (2) discoveries of the emergency functions of the organism as danger signals and safety devices for the equilibrium of the organism, brought light into this field from the physiological side. The concept of the unconscous on the one hand, and the fact-findings of the autonomic functions under emotional stress on the other hand, put the psychosomatic concept on a sound basis. Both of these principles, the physiological and the psychological one, are indispensable for an understanding of the psychosomatic concept of today. From another alley of research came welcome support for the consolidation of this concept. The animal experiments of Pavlov and his concept of the conditioned reflexes, and the more recent experiments of Lidell, Gant, Richter, Masserman and others brought convincing facts, which drew the attention of the medical men to the psychosomatic concept.

In surveying the opinions of present-day psychosomatic concept, we meet here very controversial view points. When the first issue of the *Journal of Psychosomatic Medicine* appeared, the editors wrote an editorial in which the opinion was ventured that by and large, "the whole medicine is psychosomatic, since psychic and somatic phenomena take place in the same biological system and are probably two aspects of the same process". Hence, psychosomatic medicine is rather an approach to medicine as applied to all aspects of medicine and surgery. "When the integration of psychiatry into general medicine is completed, we will no longer need the term psychosomatic because good medicine will be psychosomatic". Weiss (3). Several authors see in the name a dualism which does violence to nature because mind and body are one. It is argued that every disease is psychosomatic, for no somatic disease is entirely free from psychic influences. Fenichel (4) Binger (5). For this reason, it is proposed that the clumsy term

psychosomatic medicine would be better substituted by "The New Empiricism" or "Bio-medicine". Lewin (6). Furthermore, it would be better to have the term reserved for this category of functional disturbance, which is physical in nature and consists of physiological changes, caused by the inappropriate use of the function in question. An example would be peptic ulcer, which may be considered as the physical result of an inappropriate use of the stomach by emotional factors. "The ulcer is the incidental physiological consequence of a psychogenic attitude". This concept is not joined by others who claim that stomach symptoms of a gastric neurosis, secretory and motor, are not a substitute expression of an emotion, but its physiological counterpart, or its physiological corollary, and the peptic ulcer in itself, has nothing whatever directly to do with any emotion". Alexander (7). Another proposal comes from a well known author, Kubie (8), who wants to abandon the ominous term psychosomatic and proposes to replace it by the "all-inclusive term somatization", used now in military psychiatry, Menninger (9), as the name of any process by which a partial discharge of psychological tension occurs through the psychosomatic representation, either of the emotion itself, or of the external relationship involved, or of the conflict out of which the tension arises, or finally of the instinctive functions which give rise to the conflict. In the application of this term to the different psychosomatic disturbances, Kubie distinguishes first between external somatization, involving the external structure of the body; second, internal somatization, involving the internal organs; third, instinctual somatization, involving the apertures of the body; and fourth, diffuse somatization, involving the entire body.

In rejecting this term, another author, Masserman (10), hopes that the medical people will divest themselves of the defensive body around dualism implicit in the term psychosomatic. He expresses this opinion in the statement that our science may accept this new branch as what it is: "a study of the personal behavior of physiologically integrated human beings, interacting with the personal and social milieu, as each conceives and interprets it in terms of his own abilities and experiences". With this orientation, he thinks there need be "no bridges nor hyphen among biology, medicine and psychology, since there are no artificial boundaries to bridge". An authority in this field, Stanley Cobb (11) writes

that "psychosomatic" is by its etymology a liaison field between neurology, psychiatry and medicine. It seems to him to be a clinical field that takes up the study of the *abnormal* functions set going by emotional stimulation in any system of the body except the nervous system, and as the study of the lesions caused by such abnormal functioning. In short, simply that field of clinical medicine where the internist can help the psychiatrist and where the psychiatrist can help the internist in the study and treatment of disease.

Another leading psychiatrist, Nolan Lewis (12) finds also the term not a particularly fortunate one, but he goes further saying that psychosomatic medicine is not a speciality: "*It is not a branch* of medicine", rather a concept or a method of approach to the problem of etiology, pathology, diagnosis, and therapy, wherever they are found in the general medical and surgical specialties. However, he concedes that in any attempt to evaluate a patient psychosomatically, a methodological study is necessary; first, of the personality; second, of his method of adapting to life's situations; third, of those details of the family history, that may have a bearing on the problem; fourth, of the manner in which the illness develops; fifth, of the possible immediate precipitating factors; and sixth, of the nature of the physical rigor or rigors upsetting the situation for possible emotional conflict. It should further be investigated whether the symptom is utilized in an attempt to solve some emotional conflict, and whether the pattern has been used before early in life. Last but not least, Dunbar (13) calls it a *branch of medicine* which is concerned with an appraisal of both the emotional and the physical mechanism involved in the disease of the individual patient with particular emphasis on the influence that these two factors exert on each other and on the individual as a whole. "Psychic and somatic represent two angles of observation from which the organismal unit should be studied".

It seems to me that we should not be too much concerned with whether this kind of methodological study of a patient is called a branch of medicine or not. By and large, as we see, many authors think that the term psychosomatic is only a convenience until a better term is found. If we bring the different opinions under one hat, we might say: *Psychosomatic medicine is the systematized knowledge of how to study bodily processes which are fused and amalgamated with emotional processes of the past and the present.*

It is clear that the psychosomatic concept of today takes it for granted that any organic function, not only the pathological one, can be interpreted from the psychological point of view. In applying Woodger's concept of the universe stated in his "Biological Principles" (14), to the psychosomatic concept, we will see of what one must be aware when he uses this concept in medicine. Woodger adopts "the general picture of the universe as a series of levels of organization and complexities, each level having unique properties of structure and behavior, which, though depending on the properties of the constituent element, appear only when these are combined into the higher whole. The phenomena of a higher level cannot be understood without the knowledge of the behavior of its constituents at the lower level".

In these words we find partly the answer to the question of why it took so long before the psychosomatic concept could gain ground in medicine. The phenomena of the higher level—that is, the psychosomatic behavior—were for a long time not understood because a connection of the higher level with the constituents of the lower level could not be seen. That leads us to the question of how to examine a patient to find these connections.

Various methods have been employed to obtain the right information about psychosomatic disorders from the psychological point of view. I remind you of Whitehorn's (15) writings on interviewing. All of them tend to get an understanding of the patient's social, vocational, family (early and present), sexual adjustment including physiological and psychological behavior. The first method which I should like to call "the double track method" is the commonest. The clinical examination is made by one examiner, the psychiatric examination by another. The findings so obtained are then evaluated for their possible interrelations. It is easy to see that such construction would at times become arbitrary guesswork, and will often not correspond to the facts.

The second method is to search out in the patient's life all the possible emotional experiences that might be assumed to have a traumatic effect on the patient. Then one seeks to determine whether the onset of the organic symptom coincided with a psychic trauma. It takes note of all the organic events in the patient's life as well as of all his emotional experiences. The more coincident the traumatic

emotional experiences with the organic disturbances, the more convincing are the *correlations*.

A third method is "the biographical method". Weiszaecker (16). This concept is that all illnesses are not precipitated by chance, but are motivated by intense emotional events in the individual's life. An understanding of the various phases of the organic illness depends on the ability to uncover the genesis of the emotional events concomitant with the illness. One has not to elicit the phenomena in chronological order if one has the concept that the illness is not the onset but the result of many coinciding factors. The assumption is that the only possible way to validate the principle of psychosomatic unity is to introduce the personality into the total pathology. According to this concept, some organic illnesses begin just at the turning point of biographical crises. These crises do not occur suddenly but are an integral part of the course of the individual's life. The patient's biography inextricably interweaves somatic, emotional and mental components linked to a personality. However, the biographical method does not explain the symptoms. It merely records a kind of naive observation of the behavior and the psychic reactions of the patient. It aims at finding in the life of a patient as many *catastrophes* as possible that may form an emotional background of the organic illness. Since the examiner must interpret the material of the history to correlate psychic and somatic symptoms, there is always the danger that the results will be inconclusive. Only when the patient himself is able to give the somatic and psychic interrelations as plausibly connected will the psychosomatic unity be unquestioned.

For this reason, another method called "Associative Anamnesis", Deutsch (17) has been developed which records not only what the patient says but also how he gives information. It is of consequence not only that the patient tells his complaints but also in what phase of the interview, and in which connection he introduces his ideas, complaints, and recollection of his organic and emotional distrubances. From this point of view, obtaining the material and writing the case history cannot follow the well established pattern of the ordinary medical case history. In psychosomatic diseases, we are not so much interested in obtaining as many facts as possible, as in getting information that has not been prepared for the occasion. If one properly elicits

this kind of history-taking, one learns how the symptoms developed and what the symptoms meant to the patient from early childhood. The patient is stimulated to give the information needed, when asked to describe his organic complaints, without being aware of the psychological background of his illness. He will give the material necessary for a proof of the psychosomatic unit in his illness only if he is not aware of what it reveals to us about his emotional life. If the examiner allows him to talk without being asked leading questions, the patient will usually give a detailed account of his complaint and ideas about his illness. When he has exhausted his ideas and recollections about his organic disturbances, he will stop and wait to be asked a question. The examiner waits until it is clear that the patient will not continue spontaneously. Then he repeats one of the points of the patient's last sentence in an interrogative form. Usually the examiner repeats one of the organic complaints, the last mentioned, being careful to use the same words as the patient. The patient then usually gives new information centering around his symptoms and is stimulated to further associations. He drifts into giving a communication in which he inattentively mixes emotional and somatic material.

In this type of interview, we learn a great deal about the old and the recent conflicts of the patient, how they were and are motivating his life, and how the patient reacts to people with whom he is and was living. We get hints about the family relationships of early life, clues as to how, why and when the symptoms developed, how the psychic make-up was thereby influenced, how the organic disturbances were utilized in conflict situations, and finally the rôle of the afflicted organ functions in the psychosomatic pattern.

Any psychosomatic examination is done in order to prove that the already premorbid personality used in its development certain parts of the body and bodily functions for the expression and *solution* of emotional conflicts which become later symptoms of the organic condition. It should show that the subjective bodily sensations are simultaneously symptoms of the neurosis and of the organic disease. That implies that it should be proved that the subjective symptoms of the disease follow the pattern laid down in the bodily and personality make-up. On the whole, the interview will show the fundamental, dynamic, uninterrupted interrelation of the patient with its inner and outer

environment, and, as it was pointed out before, how the phenomena of a higher level are linked up with the constituents of the lower level. From this point of view, the term "*psychogenic*" which was first so fruitful for, but later seriously blocking the application of the psychosomatic concept in medicine, becomes outmoded. There does not exist the alternative of "psychogenic or not psychogenic." The fundamental question is what is the interrelationship of certain psychological factors with certain biological ones. To make it clear: not co-existence, nor corollary, or correlation, nor parallelism of psychological factors but *interrelationship* of these factors is what we will find. More specifically, the interview should elicit the roots of the *interaction* of the emotional life and the bodily function in question, *what* led to the choice of the organic system for the expression of the conflict, and furthermore, what factors of the environment, past and present, contributed to the establishment of the psychosomatic symptom complex.

But there remain in those interviews other problems to be answered; that is, whether the patient went, in his early life, through common emotional conflicts with their concomitant organic responses, or whether the conflicts met from the beginning a less resistant organic constitution which then paved the way for the later disease and for a personality disorder. That raises the question of how far those personality disorders contribute to the deterioration of bodily functions and whether those personality disorders are specific for certain psychosomatic entities.

At present, one part of research in psychosomatic medicine goes in the direction to prove that certain specific psychosomatic disorders occur in individuals with a specific psychological constellation. Another part of research, as Whitehorn stated some years ago, appears to be in the direction of close psychological scrutiny during periods of physiological change. If the research in this direction can be carried through convincingly, it may give the answer to the X which is so puzzling in many psychosomatic entities, particularly in allergy. Let us take asthma as an example; one of the leading allergists, Rackemann (17), put it this way: "Asthma from other causes besides allergy may come from "asthmatic state" which indicates a reaction pattern which is characteristic. Let it be called X". Then he writes, "Why stop to consider an X for asthma and allergy, when another philosopher might

suggest a Y for arthritis and a Z for mucous colitis. For each person, the reaction pattern appears to be uniform and fairly constant. Is there any characteristic of the early disease which would throw light on the ultimate prognosis? Who has the X"? he asks, and continues, "What is needed is a further study of depletion including nervous exhaustion due to stress and strain to find the mechanism by which these psychosomatic disturbances will produce their symptoms. Obviously, a complicated and difficult problem. It will take many statistical studies to make sure about these things". Being consistent, Rackermann put then amongst the requirements necessary for the development of allergic symptoms, the X., i.e., "the asthmatic state", ahead of all other requirements, and let the capacity to develop sensitiveness, i.e., allergy, and the capacity to produce and to react to histamine substances, follow. Those statements show what remarkable change towards psychosomatic concepts has taken place in medicine.

Before we try to give tentatively the answers to the X, Y, and Z which Rackemann mentions, it has to be emphasized that the problem of personality specificity in certain psychosomatic entities is still incompletely solved, and some authors are skeptical about the attempt to relate definite psychosomatic pictures to definite personality structures.

As far as *asthma* is concerned, it has been suggested that the early affections of the respiratory tract, as whooping cough or frequent colds, plus its use for the expression of conflicting tendencies throughout the childhood create a personality of a specific structure with compulsive trends. Deutsch (17). The mothers in these cases are usually efficient, domineering figures who encourage the dependency, and at the same time, suppress the aggressive tendencies. Hence the conflicts underlying this interaction between the mother and child form the background for asthma. The fathers of those patients are usually passive, kind, and less efficient personalities. The asthmatic attacks tend to be precipitated by situations, conscious and unconscious ones, that stimulate those aggressive tendencies or threaten to separate the patient from the mother figure, more in the sense of the danger of an estrangement from her, due to some tabooed temptations,

to which the patient is exposed. Hence, the asthmatic seizure is an anxiety equivalent due to the fruitless attempt to eliminate a forbidden content through the respiratory tract.

The Y of Rackemann has also found some reasonable explanation. The personalities of patients with *rheumatoid arthritis* betray very often that they have a great need for motility to overcome anxiety, that they could act out and suppress their expression of hostility in the muscular apparatus, that they take the pain as a personal offense which they resent and feel as a kind of punishment against which they protest. They overcome very often aggressive impulses directed against some person, through an identification with this person. They underestimate very often the limitations of activity demanded by the somatic impairment. It is remarkable how some chronic deformative arthritis cases screen their impairment in their behavior and talk about the future although hopelessly crippled.

The specific emotional constellation of *mucous colitis*, the Z mentioned before, may be discussed at best in connection with other gastro-intestinal disorders.

The important personality trends in the *gastric neuroses* cases are intense unconscious wishes which the patient cannot admit to himself. It is thought that the stomach symptoms are conditioned by the tendencies which serve as chronic psychic stimuli to the stomach function. In other words, many patients who have a strong, unconscious need for affection, a strong desire to be appreciated and taken care of, psychologically translate these trends as the need to be fed. At the same time, they cannot admit these impulses to themselves, and as a consequence, overcompensate with a demonstration of great energy and great endeavor. They are afraid to be dependent or ineffectual. Nevertheless, their strong unconscious tendencies to be dependent cause reactions in the gastro-intestinal tract so that the stomach tries to serve a double function. It tries to serve the function of emotional reception of love as well as acting as the organ of digestion. This is too difficult for the stomach to accomplish because the need to be taken care of (fed emotionally) is acting as an unusual or foreign and constant stimulus. This stimulus is responsible for overactivity and excessive secretion beyond the digestive needs. Moreover, this "need to be fed and loved" trend is being opposed by a stronger need to reject the un-

acceptable idea of dependency and ineffectuality, and this conflict may result in stomach symptoms.

A patient with *stomach ulcers* appears outwardly to be a very active, efficient person, but proves actually to be a hungry, dependent person, whose unsatisfied cravings for love he is unable to accept. When his ambition is thwarted, or his efforts towards success and accomplishment and superiority are too strained, he will have a tendency to run for cover, to slip back into a dependent child-like attitude, and surrenders. These passive, receptive cravings, when not satisfied, and when continually repressed, actually find their expression in a primitive way. The craving for love and care, when unsatisfied, can be felt as if it were a need for food, to which the body then reacts with a kind of chronic hunger. Such a state keeps the stomach in continuous preparedness for food which it does not receive. Its muscular wall contracts, resulting in gnawing sensations and hunger pains; its mucous membrane becomes engorged with blood, and its acid-secreting glands are over-stimulated. Wolff (19).

The trend of *colitis* cases are often quite different from the peptic ulcer patients. They unconsciously feel that they have the right to take and demand, for they 'always give sufficiently'. They feel often guilty and depressed and cross, and show grief, if they cannot give something in return for what they received. This "something" they give is usually the childish substitute of bowel movements for real values, sometimes given to express their love or aggression. Sometimes there is overtidiness, overcleanliness, hoarding the foremost personality pattern.

The characteristic traits of the personality of *hypertension* appear to be an excessive need for a secure, dependent relationship, which they are unable to find or to accept. They have a weak, submissive attitude in which fear of injury, emotional isolation and suppression of hostility are prominent features. In addition there seems to be tendency to experience frustration in relationships with other people, both social and sexual.

The experience is that the chronic hypertension cases belong to the groups of overly inhibited, sensitive, yet, at the same time, intensely hostile and aggressive individuals who try to cover up their hostility.

The hypertension develops when circumscribed neurotic symptoms which serve for the draining of pent-up hostile impulses are absent.

In the main there exists a conflict between passive, dependent, feminine tendencies and overcompensatory, competitive, aggressive, hostile impulses which lead to fear and increase the flight towards the passive attitude. The patient cannot accept the passive attitude nor express his hostile impulses.

It is a question of to which degree the high blood pressure itself accounts for the characteristic personality.

Not only psychosomatic disorders but also true organic diseases were investigated concerning their personality pattern. To give only one very brief example, it was found that the psychological background of *diabetes* is in some cases the feeling of deprivation with an increase of passive personality tendencies. These passive personality trends can find their expression in many ways, depending of course, on the premorbid personality. It seems as if the reactive depression in these cases is due to the food deprivations, but the depressive factors are based on experiences of loss of love in the pre-diabetic life period, and is therefore a depression of a primary nature. Daniels (20).

In completing a discussion of the use of the psychosomatic concept in medicine, it seems to be appropriate to discuss briefly the *psychotherapeutic* use of this concept. It presupposes that the therapist becomes firstly, thoroughly acquainted with the medical and psychic tools of therapy; secondly, that he is well trained in how, when and which of these tools to use in the special case. Of course, for practical purposes, it might not be necessary to become specialized in this therapy. In medical practice, it often happens that the physician prescribes a drug, the effect of which he is not in the least aware, but which doesn't prevent that it might be a great help to the patient. The same is true in psychotherapy where so many do not know which healing device they have used when their patients claim that they feel better. "Sometimes a sudden and dramatic faith cure, may, by the very fact of its occurrence, considerably alter one's status". Whitehorn. However, the physician's surprise about his therapeutic success yields often to a belief in his magic power, and lets him make up sometimes a theory afterwards which should justify the use of his power in relation to the patient; but it is a truism that human beings want to

be cured by magic, and therefore often willingly surrender to this approach.

The *methodological* treatment of psychosomatic disorders on the other hand has a certain goal. It aims to dissociate, to free the afflicted organs from their unconscious meaning, from their symbolizations, from their abuse for defenses against anxiety, from the inhibitions as well as from their use for substitutional gratifications. When that has been achieved, we must realize, beyond that, nothing more can be done by psychotherapy to restitute the functions. However, sometimes it may be necessary to draw another organic function into an emotional setting through treatment, in order to free the diseased organs from a less desirable involvement. By and large, the treatment always aims to strengthen the personality and to enable the ego to give up the abuse of a function and to change its "body politic". In this way, even the perception of unpleasant and painful sensations, based on organic tissue changes, can be relieved.

What has to be borne in mind is that a patient will not give up his symptom, and therefore a psychosomatic disorder cannot cease, as long as the emotional setting is not reshuffled and the psychic economy rearranged and psychic energies redistributed. The disappearance of the symptoms proves that such a process has happened. It has further to be realized that in the course of the therapeutic process, the gradual disappearance of the organic expression of the psychological imbalance will be accompanied by the appearance of a transient psychic expression of this imbalance until the equilibrium is regained. That is due to the fact that the ego is still ill at ease in giving up the protective use of the body against danger from within. The emotional symptoms which a patient then shows can be either anxiety itself or a compensation of anxiety expressed in a denial of such feeling and in exaggerated self-confidence.

It is an axiom that the patient will resist any change of his choice of conflict solution as long as he feels not assured of a better solution or as long as the conflict is not solved. Therefore, the assurance of the patient by the physician that nothing is wrong with him organically can only rarely help him. What he needs, as I said, is a better conflict solution which he can accept.

In medical psychotherapy of psychosomatic disorders, we have to take into account that the treatment of the involved organic system

by drugs has to be gradually abandoned. It is incompatible with the therapeutic concept to continue the treatment of an organic function with drugs when the patient's interest in this part of the body should be dissolved. To reach the therapeutic goal, it might very often not suffice to treat the inner emotional setting alone. Then *sociotherapy* has to go hand in hand with psychotherapy. That means the environmental setting has to be handled and managed too. That is done at best by the trained social worker. The smooth function of this teamwork, sociotherapy and psychotherapy, depends on the intelligent co-operation of the two factors, doctor and social worker.

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THE USE OF THE PSYCHOSOMATIC CONCEPT IN SOCIAL CASE WORK

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The social caseworker who chooses a medical setting for the practice of her profession has an opportunity which brings both challenge and responsibility. It is challenging because she must be able to function as a social worker in a medical rather than a social work world. It brings responsibility because she must relate her social work knowledge and skills to the intricate processes of medical diagnosis and treatment which are basic in the attainment of the physician's primary purpose. Her contribution must be significantly related to this primary purpose of medical care and yet it must not lose its separate social work focus and purpose.

Throughout the history of medical social work there is evidence that it has frequently been difficult for departments of social service in hospitals to achieve this relatedness and also this separateness. Undoubtedly our own professional insecurity and our need to be accepted within this medical world were contributing factors in the relatively slow development of a sound professional focus for social work in hospitals. We were so anxious to be needed and useful that we readily accepted responsibilities which kept us occupied with activities that were appreciated by harassed administrators and busy doctors but did not help them to discover how to use us as social workers.

Changes within medicine itself have increased the specialized resources of help for the ill person and today his medical treatment may utilize the skill of several experts. Whether the multiple services of this group of professional persons can be as meaningful to the patient and as effective in bringing about his recovery as the care of a single physician depends to some degree at least upon the capacity of the group to achieve a unified approach to the problem of the patient. This means, among other things, a sharing of knowledge and understanding about the patient by all of those concerned with his care, with each expert using his own special skill in relation to one aspect of his problem.

Medical social workers appreciate the increasing degree to which

physicians are achieving competence in the recognition and evaluation of the social component in illness. Psychiatrists, a specialized group within medicine, have voiced their approval of the further integration within general medicine of psychiatric concepts and methods. Physicians have long emphasized the social worker's need to have certain basic knowledge about disease and its treatment and the psychiatric group has been active in its efforts to broaden the social worker's understanding of the dynamics of human behavior. As this fusion and interchange of experience and knowledge becomes intensified it is essential that each professional person recognize that the purpose of this sharing is to help him to do his own particular job better rather than to take on the responsibilities of another professional person. If the medical social worker, for example, attempts to incorporate incompetently the psychiatrist's method of helping she may not make available to her patient the social work services which she is prepared to give skillfully and also fail to help the patient to make use of what the psychiatrist has to offer. If the physician undertakes to carry through the social work services which his patient needs, he may overlook essential medical services and also fail to make available the specialized help of the medical or psychiatric social worker. This focusing of responsibility for the specialized aspects of a patient's total care, does not exclude the necessity for an awareness on the part of all members of the medical team of the various facets of the patient's problem.

Dr. Deutsch has focused our attention today upon the contribution of psychosomatic research to the understanding and treatment of disease. His paper has had meaning and significance for the social case workers in this audience but we have related what he has said to our own special area of professional interest and concern. The medical and psychiatric social worker's primary concern is not with the symptomatology of disease and the techniques of its treatment because the physician has responsibility for these aspects of a patient's problem and care. Her focus is upon the social factors which have helped to make the patient ill, the social problems which his illness creates for him and the obstacles which may limit his capacity to make use of what medicine has to offer. The social caseworker's frame of reference, thus, has been socially and not medically oriented

throughout the presentation by Dr. Deutsch. Our social casework concept that the individual reacts physically, intellectually and emotionally to the experiences he has as he moves through life has been deepened and given new meaning by the contribution of psychosomatic research. Our awareness that the behavior of an individual is purposive has been broadened to include the concept that "body behavior" is also expressive of the individual's way of resolving conflict. As we achieve understanding of the purpose served by illness we are able to appreciate more fully why some of our patients cannot afford to give up their physical symptoms until some more satisfying solution of their emotional conflict has been achieved. The findings made available through the psychosomatically oriented exploratory process described by Dr. Deutsch have helped us to appreciate more fully the intricate operation of the unconscious and the skill which underlies the elicitation and use of such material. We are again made aware of the precise and thoroughgoing methods of medical science as it steadily moves ahead toward greater understanding of the causes of disease and greater skill in its treatment. We have been given, through this presentation, new insight about the significance of past and current life situations which are shared with us in our own professional relationship with patients. We have been helped to recognize that tension and anxiety created by the demands made by the social environment are the outgrowth of inner as well as outer pressures. In other words, the primary contribution of psychosomatic research to the field of social casework is the more complete understanding it is bringing about the "what" of the patient's problem. It remains for us, as social workers, to define how this deepened understanding may enrich our own social work services. We cannot look to medicine for this because our function is not to offer medical therapy but rather social casework help which is both related and different.

When I define the specific professional responsibility of the medical or psychiatric social worker as that of helping the patient and his family to be more responsible in their use of the physician's services, I am really saying that a primary objective of her service is to enhance the usefulness of medical care to the patient and to help the hospital to achieve its purpose in medical treatment. I am aware that this concept is one which has provoked some criticism by the medical

profession. It has been pointed out that medical treatment is offered within the medium of the doctor-patient relationship and that if there are problems related to it the doctor, not a third person, should help to resolve them. This is a valid interpretation of the doctor's responsibility. However, there are problems in using the doctor's help which the patient may not bring to this relationship and which may even keep him from taking hold of the help the doctor can give. For example, many patients are unable to take the initial step of going to the psychiatrist without help and some retreat after the first interview because of the fears associated with psychiatry. This is especially true of the patient who finds the transition from a somatic to an emotional focus difficult. He may need a good deal of help from both physician and social caseworker before he can use this form of treatment which seems initially less useful to him than medication or some other therapeutic agent upon which he has become dependent. Dr. Deutsch has found this to be true in his own experience and he has emphasized that the social worker can render a valuable service to both patient and psychiatrist through giving this help.

Perhaps the largest number of requests from physicians for the professional help of the social worker are related to the need for more complete understanding of the social situation of the patient. Often this referral is made on the basis that the doctor does not have the "time" to explore this facet of his patient's problem. This is an unfortunate emphasis if it means that the physician is delegating this task to someone else just because he is too busy at the moment to investigate this aspect of the patient's need for help. Actually, the physician should take the initial responsibility for identifying the social component and the need for further exploration of it just as naturally as he takes responsibility for identifying the need for other special services. His referral to the social worker should not be contingent upon how much time he has but rather upon the fact that his own professional evaluation of the problem has pointed toward the need for the special skill which the social worker can bring and which he, as the doctor, actually does not possess. It is the social workers' responsibility to bring to the patient or his family her own professional knowledge and skill which will be productive, not of something better than the doctor's appraisal of the social component, but rather some-

thing different than he has perceived as the physician. The social worker sees herself not as a competing member of the medical group but rather as a contributing one.

The preparation of a social history has long been an accepted function of both medical and psychiatric social workers. We have sometimes questioned the degree to which this contribution from us has been utilized because it has often seemed that the medical care of the patient was not related to his actual social situation. We have noted in recent years, however, that our social studies have not only been read by physicians but that the understanding about the patient which we have been able to offer has actually been a part of the total body of knowledge upon which medical treatment has been formulated. As we have become more competent as social workers we have been able to carry on this function with greater satisfaction to ourselves and our medical associates and with an increased use of it as a means of bringing social work help to the patient. Initially we were so intent upon meeting the physician's desire for social data about his patient that we failed to utilize a very real opportunity to make this process of fact-finding a meaningful and helpful part of the patient's medical care. We were often made aware of our limited contribution by the physician, himself, who after reading our comprehensive social study would inquire concerning what we had been able to do about the social problems we had so aptly described. The medical or psychiatric social worker of today accepts the doctor's request for a social study as an appropriate use of her help. However, she has come to see this function as a more inclusive and dynamic service for the patient than the collection of data about him and the presentation of these to his physician. To clarify the nature of this broader service to the patient is the purpose of the balance of this discussion.

Dr. Deutsch has been associated professionally with both medical and psychiatric social workers and he has discussed with me the help they have been able to give through making available to him certain important social data about the patient. He has provided an outline for these social workers of the various types of social information which is significantly related to the patient's illness. He emphasizes the fact that his purpose in making the outline available is not to provide the questions the worker is to ask but rather to increase her

understanding and awareness of the type of social material which will be useful to him as the psychiatrist. He does not anticipate that the material which the patient contributes during the psychiatric interview will parallel that which he has presented to the social worker. This difference in the content of the two interviews it not due to the patient's conscious misrepresentation of the situation but rather it is related to the difference in the equipment of the two interviewers, and in their purpose, focus and method.

I am aware that this different use of intervewing skill by the social caseworker is not fully understood by the medical profession. During recent years our emphasis upon the fact that we do not always make a home visit as a part of a social study but we may depend entirely upon our interviews with the patient or a member of his family group in the clinic or hospital has led to some concern about this trend in our practice. It has seemed that we were attempting to be psychiatrists especially when our social studies have included references to feelings and attitudes which have been shared with us by the patient or his family. Also we have sometimes used psychiatric terms in our description of the patient's reaction to his illness and the demands which it imposes upon him. Our social studies, perhaps, have seemed to emphasize the emotional factors in the situation more than the reality factors of income and rent and housing. Does this mean that the social caseworker is trying to take over the function of the psychiatrist or does it mean that she has grown in her capacity to see her patient as a person who does react physically, intellectually and emotionally to the experiences he encounters as he moves through life? Were our earlier routine home visits as productive or real understanding of the significance for the patient of his home environment as our present use of what the patient, himself, is able to share with us about his home and relationships within his family? Medical and psychiatric social caseworkers still make home visits but this is not a routine procedure in the sense that every family is visited in order that we may get a first hand view of the patient's home situation. The home is the patient's citadel and he may not wish to have it invaded. The fact that he is ill and dependent upon us for medical care does not mean that we are welcomed visitors in his home, at least not until he, himself, can see some real purpose in our visit and becomes a part of it

through asking us to extend our interest in him beyond the hospital and into his home. When he, himself, is an active participant in the planning for our visit to his home he is much more receptive to the help we offer to him in relation to some of the problems he is experiencing at home.

In the last analysis it is the patient, himself, who has to manage this problem of illness and we are dependent upon what he, with his inner and outer resources, is able to do with the help we extend. Physicians accept the fact that medical therapy is effective to the degree that the patient is responsive to it. The "uncooperative patient" makes us aware of the fact that the patient may not be able to engage himself in the processes of medical care. When he does not choose to carry out the steps which are outlined for him, medical therapy is obstructed. Actually, the patient has this right to choose but our acceptance of this fact does not relieve us of the responsibility for extending help to him with the problems which add to his uncertainty about the choices he has to make.

It is often around this problem of making a decision that the social caseworker's help is most needed by the patient. This is not true of all patients, of course, because many are able to relate to the authoritative direction of the physician and feel relieved of the responsibility for making a decision themselves. Others, however, show an inability to accept the doctor's guidance and initially use their energy in fighting or rejecting his help.

Mrs. A. was a patient who felt that she might lose more than she would gain through completing her medical examination and thus was resisting the step of having a chest x-ray. The social caseworker had been requested by the physician to explore the social factors in her situation because it seemed probable that she had active pulmonary tuberculosis. In the beginning of the interview, Mrs. A. said quite frankly that she was almost certain the x-ray would show that she had tuberculosis and she would prefer not to know the truth about her condition. Having recently married, she wasn't "willing to have any doctor interfere with my plans." She felt the doctor might have given her a diet or a tonic but he had refused to do this until the x-ray was taken. Mrs. A. admitted that she had lost weight, felt tired all of the time and had little appetite. She thought she had been working

too hard getting settled in her new home and that all she needed was a tonic and a diet. She was sure she could find a doctor who would prescribe these but if not she would buy something at the drug store. The social caseworker commented that although Mrs. A. had come to the doctor for his professional help she seemed to have made her own diagnosis and decided upon the kind of treatment she needed. Mrs. A. was thoughtful for a moment and then replied that she did appreciate the doctor's interest in her but she was afraid that he would tell her to go to a sanitarium and that would mean the end of everything. With the caseworker's help she was able to talk about how much it had meant for her to have a home of her own and how she was looking forward to motherhood. She wondered how her husband would react to the news of her illness and whether he might become discouraged and leave her. The caseworker agreed that there did seem to be some reasons why she might not want to go ahead with her examination but wondered whether she might not also wish to take advantage of the doctor's help. Mrs. A. replied that if she actually did have tuberculosis she would probably get worse unless she did something about it and then all of her plans for the future would be ruined. She began to cry and said that she could not understand why this had to happen to *her*. For several minutes she talked about the "bad breaks" she had had during her life. The caseworker listened to Mrs. A's account of a long series of disappointing and frustrating life experiences. She agreed that there was a real reason why Mrs. A. might want the rest of her life to be different. There did seem to be something she could do about this particular crisis which might help her to eventually have the home and children she desired. Mrs. A. said she had started out to do something about it when she had come to the doctor but it just seemed to be more than she could manage. The caseworker agreed that it was hard to face the whole thing at once and really the doctor hadn't asked her to do that. Mrs. A. nodded and said that he had only asked her to have an x-ray of her chest. With some further help from the caseworker, Mrs. A. decided that even though she was afraid of the outcome she did want the doctor's help and that she could not have this unless she carried through the diagnostic procedures he had requested. She said she would carry out these steps and then see what she could do from that point on. The case-

worker described the type of help she might be able to give her at a later point when she might have to make some changes in her life and Mrs. A. said she would keep in touch with her.

The social caseworker, throughout this interview, was not unaware of the immaturity with which Mrs. A. was facing this dilemma in her life nor was she insensitive to the reality factors which made it so threatening. She noted, as Mrs. A. related her life story, a need to project blame upon others and limited insight about her own part in the various crises she had experienced. It seemed possible that Mrs. A. had suffered from the lack of love and affection throughout her life just as she had also suffered from the lack of proper food and healthful surroundings. All of these factors had relevance for the social caseworker as a part of her understanding of Mrs. A's reaction to the doctor's request for an x-ray but her professional responsibility was to help Mrs. A., with all of the limitations she had, to evaluate the situation more realistically and thus avail herself of medical help.

The professional service of the medical social worker is often utilized by the physician who has responsibility for the treatment of the patient with a gastrointestinal disorder. Miss S. had a series of hospitalizations and had achieved a fairly satisfactory recovery from the stomach symptoms which had necessitated medical and nursing care for a long period of time. She was eager to be self-sustaining and expressed reluctance about returning to her home and again becoming dependent upon her mother and sisters. Her physician felt that an opportunity to work and a satisfying work experience were important aspects of the help Miss S. would require in order to return to a functioning level again. In her interview with the caseworker, Miss S. again emphasized her hope that she would not have to be dependent upon her family. She felt that she really should be supporting her mother and sisters because they, too, were ill and unable to care for her. The case worker was impressed by the difference between this expressed wish of Miss S. to be more adequate and strong and the reality that her illness, which had made her dependent upon others for so long, had been characterized by many recurrences of the symptoms which put her to bed. She was aware that Miss S. probably had limited capacity to carry heavy responsibility and yet an opportunity to work was important for her. She noted, with interest, the fact that the patient felt her illness began when she was unable to complete her preparation to

become a nun because of an accident which made it impossible for her to go on. Miss S. said that she had felt very secure in the environment of the convent and she had never been well since she had had to give up this experience. Her family had been disappointed, too, because they wanted her to be a nun. She felt they had been critical of her failure to realize this ambition. The social caseworker helped Miss S. to talk about the kind of working situation in which she felt she would be happy and comfortable as well as self-sustaining and contributing. Quite readily, Miss S. shared her wish to work in a rectory. She said she had often thought about this possibility but had rejected it because she really should find a job where she could earn more and take care of her family. The caseworker said she could understand why it would seem this way to her but she wondered whether Miss S. might be able to begin in a less ambitious way to do this. Miss S. smiled and said that her doctor had told her she must not work too hard and he probably knew what was best for her. She agreed that she could think about earning more money when her doctor felt she was strong enough to work in a factory or something of that sort. Miss S. wondered whether the worker might be able to help her find a position as housekeeper in a rectory. She was offered this service and subsequently did carry through, with the social caseworker's help, the steps which were necessary. She was symptom free for nearly a year and then appeared in the clinic with a mild recurrence of her symptoms. Inquiry revealed that there had been a change in the staff at the rectory and that Miss S. was having difficulty in getting along with the new person who was supervising her work.

Neither Miss S's physician nor the social caseworker was surprised when she returned to the clinic at this point in her life when she was having to adjust to a less supportive environment. They continued their medical and social work services with the full realization that Miss. S. was essentially a dependent person and that when her environment made demands upon her which she was unable to meet she would again have a need to use her symptoms as a means of managing. Her return to the clinic for further help was regarded, not as evidence that she could not be a socially useful person, but rather as evidence of the fact that she might continue to need help when confronted by demands which exceeded her capacity for meeting them.

Realistically many individuals do have this problem of having to

meet the experiences of life with limited physical and emotional resources. There is need for all of us to be as creative and responsible in the use of our knowledge and skill in the rehabilitative phase of medical care as we are in the curative phase. Psychosomatic research has a good deal to offer social caseworkers in terms of understanding of the emotional needs which handicapped persons bring to the experience of meeting the reality demands imposed upon them by their chronic disease. In the case of the diabetic patient, for instance, psychosomatic research has suggested the possibility that the patient may be limited in his capacity to assume the degree of responsibility required by a diabetic regieme because of his basic need to be dependent. We are not always aware of this possibility, particularly when we confine our evaluation of the diabetic patient's capacity to manage the regieme outlined for him to a consideration of his intellectual equipment and economic resources. Many diabetic patients are able to grasp intellectually the dietary requirements of their disease and yet are unable to assume responsibility for the control of what they eat. Others learn how to use the insulin syringe quite readily and yet are reluctant to be responsible for this aspect of their daily routine. In fact, many of these patients seem to depend a great deal upon their relationship with the person who administers the insulin. Social caseworkers have observed that a premature termination of their own helping relationship with the diabetic patient may be followed by a progressive lessening of his ability to manage his regieme. We need to be aware of the fact that the benefit of the physician's knowledge about diabetes and its control and the value for the patient of the specific routine worked out by his doctor may be lost entirely if we are not sensitive to the patient's need for supportive help at the point when he must assume such a high degree of responsibility for his own care. Too often the social caseworker has terminated her help when it has seemed certain that the diabetic patient understood his diet, when he has learned how to use his syringe and has assured those concerned with his care that he can purchase insulin and proper food. It has often seemed that the basic essentials have been met and that the patient is equipped with the things he needs for the experience of living with diabetes. Actually, he may need the help of the social caseworker at the point when he takes on this new responsi-

bility more than at any other time because of what she can offer in terms of support, recognition and encouragement.

The social caseworker's service to the patient who has to cope with the problem of living with chronic disability often includes the use of employment and vocational resources within the community. Psychosomatic research has contributed to the social worker's understanding of the emotional needs which handicapped persons bring to the reality experience of utilizing special employment opportunities and other services designed to help them cope more adequately with the problem of living with a damaged heart or stiff joints or a psychoneurosis. This understanding will enrich our services through helping us to be more sensitive in our selection of the resources within the community which will have maximum usefulness and benefit for the patient. A sheltered workshop, for instance, may impose emotional strain upon the patient whose need for status and recognition may not be met in this protected situation. A position as an elevator starter may have infinitely more emotional value for the individual who needs to be the "boss" than a job as the operator of an elevator. As we noted in the illustration of Miss S., it was important for her to be helped to find an employment situation which would meet her emotional, as well as her economic needs.

The problem of physical restoration, with all that this includes in its broadest sense, is the responsibility of medicine and its specialities. The social caseworker's task is that of helping the individual to make the best use that he can of himself and his potentialities within the social world of which he is a part. The future holds rich promise for increased effectiveness on the part of both medicine and social work as we continue to grow in understanding and in our professional capacity to help individuals face the problem of disease and cope with the impact of it upon his living.

THE ELIMINATION OF POLIOMYELITIS VIRUS FROM THE HUMAN MOUTH OR NOSE*

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The precise pathways pursued by poliomyelitis virus in travelling from the infected host to the susceptible individual have not been clearly defined. Although there is considerable evidence in favor of the intestinal-oral circuit, the respiratory channel (droplet infection) has not been discarded from consideration as an important mode of transmission.

This paper reports an experiment designed to answer the question: Can poliomyelitis virus be eliminated from the mouth? The question is asked because, although poliomyelitis virus has been recovered from washings of the nasopharynx (1–6), and oropharynx (3) (7) (8), from swabs of the pharynx (9) (7), and from the pharyngeal wall with or without the tonsils (10–14) there is no published evidence that it is actually expelled from the mouth under natural conditions. Indeed, a previous study failed to detect virus in saliva and oral secretions of 20 patients in the first two weeks of paralytic disease (15).

MATERIAL AND METHODS

Tests were carried out on material from 19 patients in the early stages of poliomyelitis acquired in an epidemic during the summer of 1945[1]. Because Howe and his associates were able to isolate poliomyelitis virus with considerable frequency (43%) from pharyngeal swabs taken during the first three days of illness and not thereafter (9), this early phase was thought to be perhaps one of critical epidemiological importance, and therefore worth emphasizing in the present study.

Collection of Material

Material was obtained from 13 patients on the second, from 5 on the third, and from one on the fourth day of illness. Eight patients exhibited weakness

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or paralysis at some time, and 11 had an illness compatible with non-paralytic or abortive poliomyelitis (Table 2).

Firstly, a sterile cloth mask was tied over the patient's mouth and nose for one-half hour during which he was induced to talk, blow, cough and expectorate into the mask. Most of the subjects cooperated so that the mask became visibly wet. The central wet portion was then cut out with sterile instruments and placed in a sterile lusteroid tube containing one ml. sterile distilled water. Secondly, the nose was swabbed with two sterile cotton swabs[2] and lastly two swabs of the tonsillopharyngeal area were taken and similarly stored. These materials were either frozen immediately with solid CO_2, or refrigerated for one or two hours and then stored in the frozen state until prepared for inoculation.

Preparation for Inoculation

Before attempting to extract human virus from the masks, a preliminary experiment was designed to test the proposed method. Since it was important to know if *minimal* quantities of virus could be detected on the mask, titrations of a poliomyelitis-like virus[3] pathogenic for mice were carried out after the virus had been added to sterile cloth masks of the same type used in the human tests. Extracts of masks made with distilled water were compared to masks extracted with a 0.0001 normal sodium carbonate solution at pH8 and adjusted to about pH4 before inoculation. The latter procedure was patterned after that described by Wenner for the elution of Lansing virus from cotton swabs (16). Thus, serial ten-fold dilutions of a 10% suspension of infected mouse brain were prepared in sterile distilled water. Starting with the 10% suspension, 1 ml. of each dilution of virus was pipetted on to each of 2 masks. One mask was extracted with 9 ml. of distilled water and the other with 9 ml. of sodium carbonate solution at pH8. This was repeated with each concentration of virus, so that the final theoretical concentrations of virus in the extracts were 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}, and 10^{-6}. Control titrations of virus in distilled water and in sodium carbonate solution at pH8 were carried parallel with the mask extracts. The results are shown in Table 1. Extraction of masks at pH8 was clearly superior to extraction with distilled water and when compared with the control suspensions (no mask), showed practically no loss of virus. Hence this method was adopted for the preparation of the human materials.

Each mask used in the human test was shredded with scissors and to it was added 8 ml. of a sterile 0.0001 normal sodium carbonate solution at pH8, pounded briefly in a mortar, and the fluid expressed by means of a 50 ml. syringe with a copper wire gauze inside the barrel covering the nozzle. This was designated the *first extract*. It was centrifuged in an angle head (New International) at 4,000 R.P.M. for one-half hour. To the supernatant fluid was added 15% anaes-

[2]Each nasal passage was entered to the depth of 1 to 2 inches. No attempt was made to reach the nasopharynx.

[3]Immunologically closely related to Theiler's FA strain.

thetic ether and the mixture was shaken and stored overnight at 3°C. The following day the ether was removed by bubbling air through the extract; the pH was adjusted to about 4 by the addition of 2% acetic acid and the material was inoculated into two monkeys by the intracerebral route. The *second extract* was prepared immediately after the first by adding to the mask another 8 ml. of sodium carbonate solution at pH8 and expressing it in the same fashion. To this extract was added the sediment obtained from the first centrifugation, and the mixture was given intranasally to the same monkeys.

The nasal and pharyngeal swabs were prepared in the same fashion, 2 ml. of sodium carbonate solution being used to extract them. Cultures of all the etherized materials were usually sterile.

TABLE 1

Titration in Mice of Poliomyelitis-like Virus in Masks Extracted With a) Sodium Carbonate Solution at pH 8 Compared With b) Distilled Water*

SUSPENSION	FINAL CONCENTRATION OF VIRUS					LD 50 TITRE (LOG OF DILUTION)
	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	
Control, dist. water	6/8†	8/8	8/8	4/8	2/6	5.2
Control, pH 8	7/7	8/8	8/8	8/8	1/8	5.6
Mask extract, pH 8	8/8	8/8	7/8	6/8		5.2 or more
Mask extract, dist. water	8/8	6/8	3/8	0/8		3.6

* The virus used in this experiment was pathogenic for mice and immunologically closely related to Theiler's FA strain.

† Numerator equals number of mice exhibiting signs of CNS involvement, denominator number inoculated.

Inoculation of Monkeys

Immature rhesus monkeys (Macaca mulatta) weighing 3 to 5 kilograms were used throughout. Intracerebral inoculation was performed under ether anaesthesia, the inoculum varying between 1 and 2 ml. Two monkeys were employed to test each of the masks, and one monkey for each of the nose and throat swabs, respectively. Most of the animals receiving the mask extracts were reinoculated after 1 or 2 weeks if no signs of illness had appeared before. It was felt that these procedures would favor the detection of virus in the mask, should any be there.

The second extract (unetherized), plus the sediment from the first extract, were instilled intranasally (1 ml. in each nostril) daily for two days in respect to the mask and for one day in respect to the nose and throat swabs. The olfactory bulbs of all monkeys were examined and typical lesions of poliomyelitis were found in the bulbs of the two animals inoculated with the mask extract of patient #2 (Table 2), suggesting that the nasal administration may have helped to secure positive results.

Criteria for the Detection of Poliomyelitis Virus

The diagnosis of poliomyelitis in the monkey was made on exhibition of weakness or paralysis of one or more extremities confirmed by characteristic histological lesions in the central nervous system (CNS)—namely, necrosis of nerve cells, neuronophagocytosis, and perivascular cellular infiltration. Paralyzed monkeys

TABLE 2

Results of Tests for Poliomyelitis Virus in Material from Nose and Throat

PATIENT	AGE (YEARS)	TYPE OF ILLNESS	NO. WBC IN CSF	DAY OF ILLNESS	VIRUS DETECTED IN		
					Throat	Nose	Mask
1	13	P*	360†	2	0/1‡	1/1	1/2
2	4	P	N.D.§	2	1/1	0/1	2/2
3	2	P	36	2	1/1	0/1	0/2
4	7	NP	50	2	1/1	0/1	0/2
5	17	NP	0	2	1/1	0/1	0/2
6	8	NP	61	2	1/1	0/1	0/2
7	5	NP	59	3	1/1	0/1	0/2
8	7	P	58	2	0/1	0/1	0/2
9	5	P	60	3	0/1	0/1	0/2
10	4	P	34	3	0/1	0/1	0/2
11	14	P	B¶	3	0/1	0/1	0/2
12	4	P	N.D.§	4	0/1	0/1	0/2
13	21	NP	3	2	0/1	0/1	0/2
14	8	NP	466	2	0/1	0/1	0/2
15		NP	0	2	0/1	0/1	0/2
16	9	NP	7	2	0/1	0/1	0/2
17	15	NP	8	2	0/1	0/1	0/2
18	11	NP	80	2	0/1	0/1	0/2
19	4	NP	5	3	0/1	0/1	0/2

* P = paralytic.
NP = non-paralytic.

† Number of white blood cells in the cerebrospinal fluid.

‡ Numerator: number of monkeys positive clinically and pathologically for poliomyelitis. Denominator: number of monkeys inoculated.

§ N.D. = no spinal fluid cell count recorded.

¶ Lumbar puncture resulted in a bloody tap.

were sacrificed soon after the appearance of paralysis, all others between 5 and 6 weeks after inoculation. Histologic examination of the latter brought to light no examples of non-paralytic poliomyelitis. Portions of the CNS of the monkey paralyzed after receiving extract of mask of Patient No. 1 were passaged to a second monkey, to 10 mice, and 3 guinea pigs. The monkey developed typical poliomyelitis while the other animals remained negative.

RESULTS

Poliomyelitis virus was detected in the masks of two of the 19 patients (Table1). This finding indicates that it can be expelled from the mouth or nose at least in some patients under the circumstances described. In one of these patients (# 1) virus was also recovered from the nasal swabs, and in patient # 2, from the pharyngeal swabs. Virus was isolated from the pharyngeal swabs alone in 5 additional subjects. All tests were negative on the 12 remaining individuals.

Virus was found, with one exception, in materials obtained on the second day of illness from patients 3 of whom had paralytic and 4, nonparalytic poliomyelitis. Although both positive masks were derived from paralytic patients, the numbers are too small to attach any significance to this finding.

DISCUSSION

The recovery of poliomyelitis virus from cloth masks into which patients had expelled material from the mouth and nose indicates that virus can be eliminated, at least under the conditions of this experiment, from the mouth or nose. This is believed to be the first demonstration of virus elimination from these portals under circumstances which come fairly close to being natural. An important question is: What is the epidemiologic significance of this finding? Or, in other words, does this mean that the disease is transmitted by droplet infection? The answer obviously cannot be given in straightforward terms since many pertinent facts are still unknown. One might argue that the demonstration of elimination of virus from the mouth or nose supports the theory of *contact infection*, for which circumstantial evidence has been described recently by Aycock, et al (22) and by Casey and associates (23). On the other hand, if infection were usually acquired by aspiration of droplets it is not unreasonable to suppose that the nasal pathway, in particular the olfactory, would be utilized. That this does not usually appear to be the case has been amply demonstrated (17) (13) (18) (14) (19). The failures to detect virus in the human nasal mucosa (13) and the experiments in which nasal chemoprophylaxis failed to alter the incidence of the disease (20) (21) may be cited as additional evidence against any part of the nasal mucosa

serving as the area of primary attack. It is conceivable that virus, although aspirated by way of the nose, may actually penetrate the mucous membrane of the pharynx or lower alimentary tract.

Although contact infection seems to occur in some cases of poliomyelitis, the nature and degree of contact necessary for transmission are unknown. To many the term "contact" implies "respiratory contact" or droplet infection. It should be remembered that, generally speaking, contact infection can also take place along other channels, for example, the intestinal-oral.

The present experiment was undertaken with the expectation of negative results. It was felt that the balance of evidence pointed away from poliomyelitis being spread like a respiratory disease. It seemed that the presence of virus in the pharynx and its absence from the nose might conceivably have an analogous epidemiologic significance to that described by Hamburger et al in regard to the streptococcus (24). These authors have shown that the "dangerous" carriers of the hemolytic streptococcus (i.e. those individuals who discharge organisms into the air), are the *nasal* carriers in contrast to the pharyngeal carriers who are not "dangerous". The frequency of elimination of poliomyelitis virus from the mouth or nose is unknown, for the number of tests in the present report and the methods employed for detection of virus may both be inadequate. Nor has any attempt been made in this study to determine if virus is eliminated from these portals at still earlier or later stages of infection.

Lastly, the recovery of virus from the nasal swab of one patient (#1, Table 1) whose mask was also positive is open to several interpretations: a.) virus was present and multiplying in the nasal mucosa, b.) the swab had penetrated as far as the nasopharynx and virus was obtained from the pharyngeal component, and c.) virus was in the nasal passage as a result of being aspirated from the mask or expelled from the pharynx. Recent evidence (13) (14) (15) is against (a). The technique employed in swabbing the nose while not precluding it, makes (b) unlikely. Inasmuch as the nose was swabbed *after* the mask had been in place for some time during which forceful expulsion of material from the throat was taking place, the third possibility appears to us as the most likely. It is recognized that no virus was obtained

from the throat swab in this case but perhaps that may be explained on the use of only one monkey for the test (25).

SUMMARY

1. Poliomyelitis virus has been demonstrated in material expelled from the mouth (or nose) of two patients out of 19 studied. This was achieved by having patients blow and spit into cloth masks from which virus was extracted.

2. Virus was also detected in nasal swabs of the first patient and pharyngeal swabs of the second patient shown to have eliminated virus from the mouth or nose.

3. In five additional patients virus was isolated only from swabs of the pharynx.

4. Certain implications of these findings have been discussed. It is to be emphasized that their epidemiological significance or insignificance is yet to be be determined.

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